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ABSTRACT

This volume contains a collection of working papers designed to accompany the case studies of India and Latin America in providing a framework for the planning of educational broadcasting systems. The first two papers offer useful orientation to policy-makers who are considering educational television. Working Paper No. 3 compares the two media of instructional television and film with respect to educational effectiveness and economics of production and distribution. The fourth paper reminds us that communication depends on limited international resources and there are a finite amount of frequency spectrum available and a limited number of "parking slots" for satellites in synchronous orbit. Therefore, conservation must be practiced if maximum benefit is to be derived from what are properly world resources. Characteristics of organizational settings typically found in developing countries are discussed in the fifth paper. Working Paper No. 6 describes and documents the economic analysis used in estimating cost elements of educational television systems. The joint use of both educational television and radio, with radio as a backstop for television was the subject for the seventh and final paper. (HAB)

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August 1968

Volume IV

SATELLITE-DISTRIBUTED EDUCATIONAL TELEVISION FOR DEVELOPING COUNTRIES – WORKING PAPERS

Prepared for:

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WASHINGTON, D.C.

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PREFACE

In March 1968, the U.S. Agency for International Development, in support of the President's Task Force on Communications Policy, contracted with Stanford Research Institute to study educational applications of communication satellites for developing countries. The study was designed to determine the potential of satellite-delivered educational broadcasts through analyses of two developing regions. A single large nation, India, and a multinational region, Latin America, were chosen as case studies to illustrate the scope of possible applications. The emphasis of the case studies was to be on the educational, economic, cultural, organizational, and political factors affecting the feasibility and utility of satellite communication.

This report contains working papers relevant to the study. Volumes in the project series include:

Volume I:	Satellite-Distributed Educational Television for Developing Countries--Summary
Volume II:	Communication Satellites for Education and Development--The Case of India
Volume III:	Satellite-Distributed Educational Television for Developing Countries--The Case of Latin America

Volume IV: Satellite-Distributed Educational Television for Developing Countries--Working Papers

1. Nonhardware Components of an Instructional Television System for a Developing Country
2. Considerations in Deciding Whether and How to Introduce an Educational Satellite
3. Film Versus Television in Education
4. Technical Considerations of Satellite Communication Systems for Education
5. Political Obstacles to Adoption of Educational Television
6. Economic Analysis of the Alternative Distribution Systems for Educational Television
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INTRODUCTION

by William J. Platt

This volume contains a collection of working papers designed to accompany the case studies of India and Latin America in providing a framework for the planning of educational broadcasting systems.

In the first two papers, Professor Schramm offers useful orientation to policy-makers who are considering ETV (educational television). His discussion of nonhardware components stresses the importance of allocating major planning and organizational effort to educational and program production matters. They, more than the physical technology, determine the ultimate feasibility of educational applications of broadcast media.

Instructional films clearly have some relationship to instructional television. In Working Paper No. 3, Professor Schenkkan compares the two media with respect to educational effectiveness and with respect to the economics of production and distribution.

B. R. Stack, in Working Paper No. 4, reminds us that communication depends on limited international resources, that is, there are a finite amount of frequency spectrum available and a limited number of "parking slots" for satellites in synchronous orbit. Interference considerations limit the power that can be radiated to and from a satellite. Therefore, conservation must be practiced if maximum benefit is to be derived from what are properly world resources. Mr. Stack also calls attention to the amount of lead time that would be required to restore service in the event of failure of some aspect of a satellite communications system.

Organizational and political adjustments of some magnitude are associated with the adoption of a large scale innovation like ETV. Professor Benveniste, in Working Paper No. 5, discusses characteristics of organizational settings typically found in developing countries. Drawing on these characteristics, he analyzes obstacles likely to have to be overcome if ETV is to become an integral part of the instructional system.

In Working Paper No. 6, Andrew J. Lipinski describes and documents the economic analysis used in estimating cost elements of educational television systems. Computer-based cost models were developed to provide the flexibility for exploring a wide range of demand levels, geographical coverages, network configurations, procurement policies, launch strategies, and other options.

The project team interpreted the scope of the study to place major emphasis on the television medium rather than radio education, largely on the basis that the medium offering both visual and audio signals has the greater learning impact and is of more interest for satellite distribution. Since radio has an interesting capability to support or anticipate ETV, Andrew D. Cohen was invited to prepare Working Paper No. 7, which deals with the joint use of the two media and with radio as a backstop for ETV.

Working Paper No. 1

NON-HARDWARE COMPONENTS OF AN INSTRUCTIONAL TELEVISION SYSTEM FOR A DEVELOPING COUNTRY

by Wilbur Schramm

When most of us think of instructional television, we think first of the hardware and electronics of the system -- the dancing lights on the picture tube, the transmitter tower, the studio building, the cameras, and so forth. When such technology is introduced into a developing country, where even a chalkboard may be a luxury, the hardware is doubly impressive. Yet those of us who have worked with this teaching-learning system know that television's only really significant contribution to the system is a method of delivery, and its effectiveness depends largely on the non-hardware components built around the delivery chain. We have also seen attention and concern typically focus on the hardware, to the neglect of the rest of the system. In the following pages, therefore, let us turn our attention to the non-hardware elements of an ITV system.*

The essential purpose of such a system, when it is used for education, is to share teaching and demonstrations very widely. Functionally the system can be visualized thus:

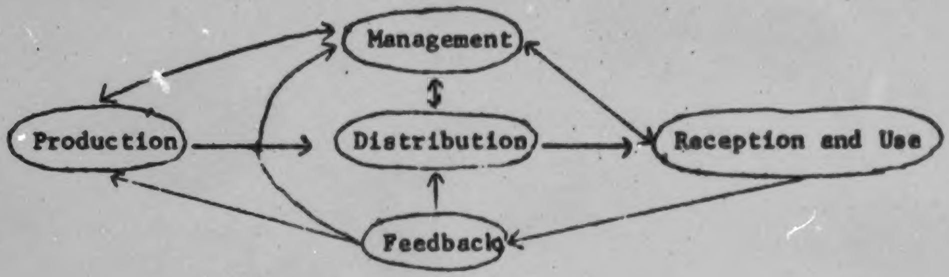
---

* Throughout this report ITV refers to ETV in which reception is organized, as in a classroom or telecenter.

Under policy control and direction of management

teaching and demonstrations are produced at a central place. These are picked up and → shared widely with → users in many places, who build around the broadcasts a context of learning activity from which → reports on the effectiveness of the programs go back to those responsible for producing and distributing them.

By naming these functions we can describe a structure for the system:



It is obvious that there is a great deal of hardware in this system -- the studio equipment, the transmitter and the tower, the receiving sets, and so forth -- and that it represents a large capital investment. What may not be so readily understood is that the greater share of the operating costs do not go for hardware, and only a small share of the people working in the system are concerned directly with hardware. To illustrate this, let us describe some of the components of an ITV system as it actually exists in a developing country.

The Human Components

Five hundred forty-six individuals were engaged in operating the instructional television system in American Samoa, when I studied it.

The system in American Samoa is not completely typical of most other ITV systems. It is better financed, for one thing. It has more hardware -- six open-circuit VHF channels, four studios, 10 large videotape recorders. It has less audience than most systems, although it serves all the 8,000 elementary and secondary school pupils on the islands of American Samoa. Many systems reach vastly larger audiences -- for instance, Colombia now delivers ITV to nearly 500,000 students -- but few ITV systems, either in developing or economically advanced countries, have six open-circuit channels that cover the entire educational system. Furthermore, Samoa is unlike many systems in that it has chosen to carry the core of the entire curriculum, rather than a few courses, on television, and because the television is so completely built into the school organization and the school activities that it is truly a part of ongoing education, not something brought in from the outside to supplement what would go on anyway. Because of this, and because the population served is relatively small, Samoa is a good example for our purposes, inasmuch as it permits us to examine closely all parts of a fully developed system.

Of the 546 employees, only about 130 were persons whose jobs would not exist if there were no television on the islands. The remainder were school employees -- teachers, teacher trainees, school officials, service employees, and so forth. This is an important figure, because the persons who are in charge of the pupils in the classroom, and responsible for the context of learning activities built around the picture tube, are an essential part of an ITV system, just as surely as the people who broadcast in the studios, or those who turn the switches on the transmitter. If they do not do their job well, the system does not work well. In Samoa, four people work on reception and use, for every one that works on production. In a widespread system like that of Colombia, the proportion would be over 50 in reception to every one who works in production. Here are the approximate distributions of personnel in the Samoa system:

Management
18 (3%)

Production
106 (19%)

Distribution
25 (5%)

Reception and Use
395 (72%)

Feedback
2 (1%)

Here are the human components in greater detail:

Management

Director, assistants, financial officers, secretaries.

Production

- 21 studio teachers
- 9 teachers to prepare materials to go with the broadcasts
- 44 producer-directors and members of studio crews
- 15 supporting production personnel -- writers, photographers, artists, librarians, publication manager, typists
- 17 engineers and technicians

Distribution

- 20 engineers and technicians
- 5 drivers and other supporting personnel

Reception and Use

- 283 teachers
- 56 teacher trainees
- 8 curriculum supervisors
- 30 principals and assistant principals
- 7 engineers and technicians to repair receivers and antennas
- 7 maintenance personnel

Feedback

Research officer and assistant

About 98 per cent of all these persons require special training; 65 per cent of them are truly professionals who need many years of training. Only 45 of them (9 per cent) would be classified as technical personnel.

Reflect for a moment upon the human components of the system we are describing. They are numerous. Most of them require special skills which come only from systematic training. Most of them are not technical personnel. Furthermore, the larger part of them are not under direct control of television management at all. At most, only a few hundred of the people who work in any instructional television system are likely to work for television. A far larger group will be employed by the schools. Through this latter group, and with them, the people concerned with television production and distribution are trying to serve a still larger group -- the 30 to 50 pupils of each teacher, who are the reason for the system's existence.

Thus, in broad terms, the human shape of an ITV system looks like this:

(Samoa)	about 140	→	about 400	→	about 8,000
(Colombia) (estimated)	200	→	12,000	→	500,000
(A direct-broadcasting satellite ITV system, as it might be)	400	→	250,000	→	10,000,000

Even a cursory look at these figures tells us much about the human requirements of this kind of system. By the nature of the system, a few people in a central producing position must strike up a cooperative arrangement with a much larger number of persons at some distance away, in order that they together can serve a vastly larger number of persons who are the ultimate users of the system. The people who are at the second step in this arrangement are not only some distance removed, but also likely to be working for an entirely different employer and to feel some resentment at having their routine interrupted by "outsiders". In a developing country, the people in television production and the people in the classrooms are likely to be working for different -- and sometimes uncooperative or even antagonistic -- ministries. Therefore, among the things one looks for in such a system is the kind of cooperative activities and the amount of communication maintained between the producers and the school personnel, and whether the system is organized to make understanding and cooperation as easy as possible.

Let us turn for a moment to the matter of organization.

Organization of the System

The organizational chart for an ITV system will not look exactly like the structural chart we presented a few pages back. By long tradition, noncommercial television operations have been organized, under management, in two main units, headed respectively by a program director (or some equivalent title) and a chief engineer. The engineers and technicians report to the chief engineer, whether they are assigned to the studios, the master control, the transmitter, or maintenance of the receiving equipment. The production personnel will report to the chief program officer, whether they are "talent", writers, producers, or specialists in some kind of materials.

This aspect of organization, however, need concern us less than the place likely to be given the ITV system, in a developing country, among other agencies and activities of government. In the following pages we are going to illustrate several patterns for doing this.

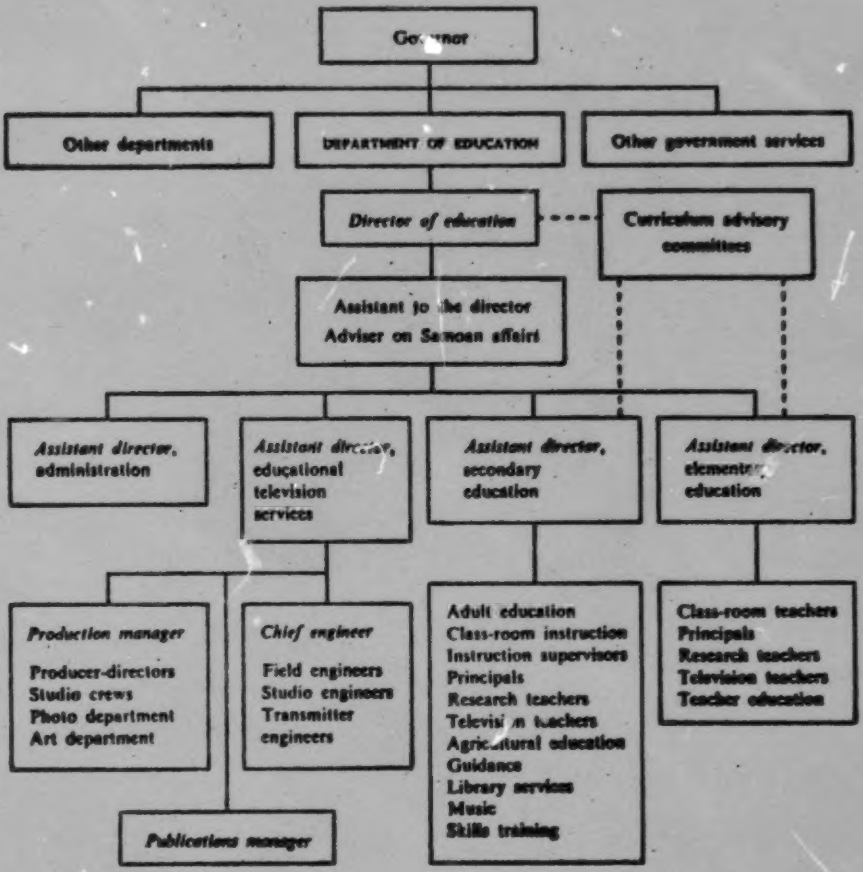
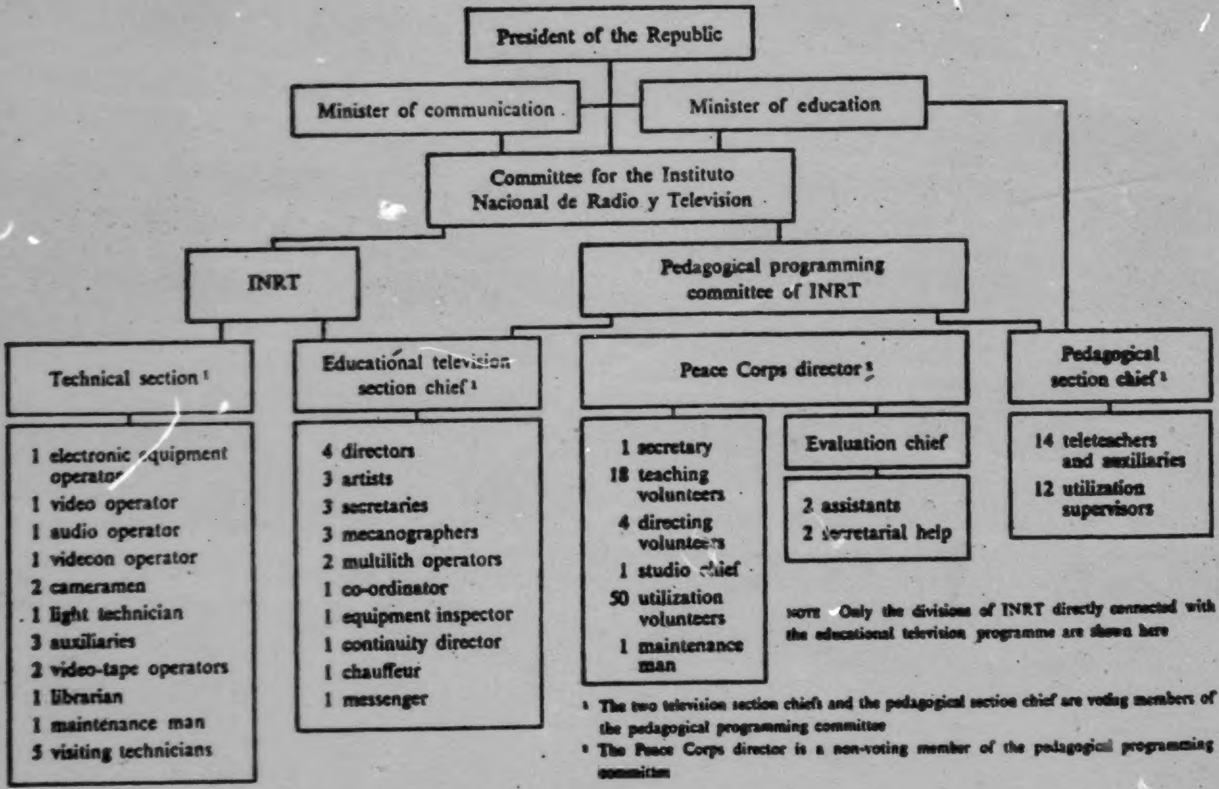

Governor
Other departments
DEPARTMENT OF EDUCATION
Other government services
Director of education
Curriculum advisory committees
Assistant to the director
Adviser on Samoan affairs
Assistant director, administration
Assistant director, educational television services
Assistant director, secondary education
Assistant director, elementary education
Production manager
Producer-directors
Studio crews
Photo department
Art department
Chief engineer
Field engineers
Studio engineers
Transmitter engineers
Publications manager
Adult education
Class-room instruction
Instruction supervisors
Principals
Research teachers
Television teachers
Agricultural education
Guidance
Library services
Music
Skills training
Class-room teachers
Principals
Research teachers
Television teachers
Teacher education

FIGURE 1. *Organization of the Department of Education in American Samoa*

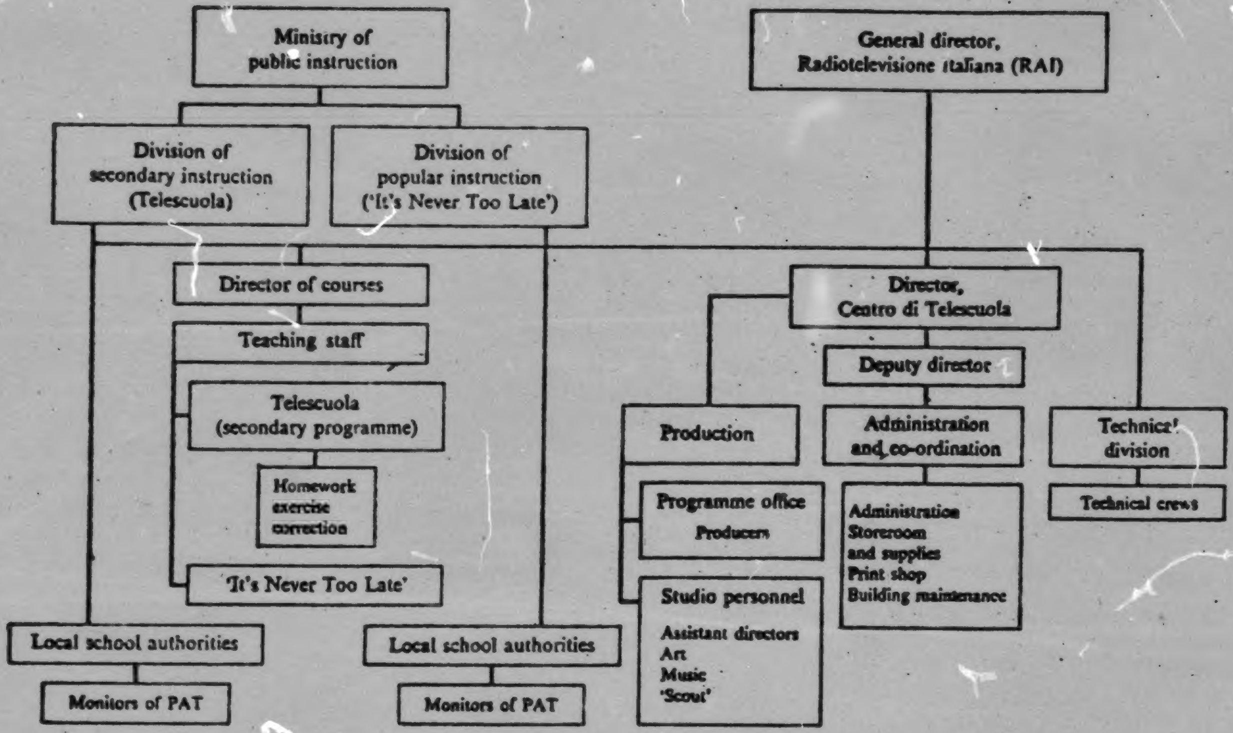

President of the Republic
Minister of communication
Minister of education
Committee for the Instituto Nacional de Radio y Television
INRT
Pedagogical programming committee of INRT
Technical section[1]
Educational television section chief[1]
Peace Corps director[2]
Pedagogical section chief[1]
1 electronic equipment operator
1 video operator
1 audio operator
1 videcon operator
2 cameramen
1 light technician
3 auxiliaries
2 video-tape operators
1 librarian
1 maintenance man
5 visiting technicians
4 directors
3 artists
3 secretaries
3 mecanographers
2 multilith operators
1 co-ordinator
1 equipment inspector
1 continuity director
1 chauffeur
1 messenger
1 secretary
18 teaching volunteers
4 directing volunteers
1 studio chief
50 utilization volunteers
1 maintenance man
Evaluation chief
2 assistants
2 secretarial help
14 teleteachers and auxiliaries
12 utilization supervisors

NOTE Only the divisions of INRT directly connected with the educational television programme are shown here

[1] The two television section chiefs and the pedagogical section chief are voting members of the pedagogical programming committee

[2] The Peace Corps director is a non-voting member of the pedagogical programming committee

FIGURE 1. *Organizational structure of the Colombian educational television programme*



Ministry of public instruction
General director, Radiotelevisione italiana (RAI)
Division of secondary instruction (Telescuola)
Division of popular instruction ('It's Never Too Late')
Director of courses
Teaching staff
Telescuola (secondary programme)
Homework exercise correction
'It's Never Too Late'
Director, Centro di Telescuola
Deputy director
Production
Administration and co-ordination
Technical division
Technical crews
Programme office
Producers
Studio personnel
Assistant directors
Art
Music
'Scout'
Administration
Storeroom
and supplies
Print shop
Building maintenance
Local school authorities
Monitors of PAT
Local school authorities
Monitors of PAT

Figure 2. *Italy's Centro di Telescuola*

In Samoa it was decided that television was to be part of education. It was to be completely integrated into the curriculum and into classroom teaching. Therefore, the chief officer in charge of television had to be the Director of Education. The assistant director in charge of television services is a part of a cabinet concerned with all aspects of education on the islands. The directors of elementary and secondary education are as concerned with the television teaching as with the classroom teaching. This same pattern is seen in other countries where the Ministry of Education has its own broadcasting facilities, and in the large ITV installations owned by school systems within the United States -- for example, Hagerstown (see New Educational Media in Action, vol. I, p. 63).

The more typical pattern, however, is that educational television rents or is assigned a certain amount of time on television facilities which are under control of some Ministry or agency other than Education. For example, La Telescuela Popular Americana, of Peru, rents time on a commercial outlet. In Nigeria, in the Ivory Coast, in Colombia, to take a few examples, instructional television is assigned time on the national stations, some of which are supported by commercial advertising.* These facilities are typically under the

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*This is the typical pattern of open-circuit ITV in the United States, in the numerous cases where stations are not owned by school systems. These stations typically broadcast for the general audience in late afternoon and evening hours, and to classrooms during the school day. The schools are asked to determine the curriculum and the content of these broadcasts, and to contribute their cost to the station.

Ministry of Information. But the Ministry of Education is understandably sensitive to the control of teachers and teaching materials. Therefore, a variety of patterns has been developed to share the control over the instructional television.

One of these patterns is that of Colombia. A National Institute of Radio and Television has been formed to represent both the Ministry of Communication and the Ministry of Information. This organization produces the programs. Its pedagogical committee determines the curriculum and the content, and together with the Ministry itself chooses and supervises the teachers who appear on television. There is one uncommon feature in the Colombian organizational chart: The U.S. Peace Corps contributes a number of utilization volunteers to the system. These are individuals who work with classroom teachers in helping them to make effective use of the broadcasts. The volunteers are under the Peace Corps director and therefore not directly responsible to any of the Government ministries.

A still more common pattern is illustrated by Italy, which is, to be sure, not classified as a developing country, but which has had a long experience with instructional television that is now being mirrored in some developing countries. The Centro di Telescuola came into existence simply as the television school for secondary education, a unit for secondary vocational instruction within the Italian broadcasting network. Trying to help solve the country's educational problems, the director of the broadcasting system made plans to bring education to teen-agers who lived beyond the reach of existing schools.

A lyceum professor who had been active in radio courses for a number of years was hired to develop such a program, a staff was assembled, and the Telescuola went on the air in the late 1950's. With the formalization of this program, however, the Ministry of Public Instruction became increasingly concerned with and involved in it, and the Centro di Telescuola was set up as an independent unit in the network. The technical personnel are provided by RAI, but all the pedagogical activities and policies are controlled by the Ministry of Public Instruction. This Ministry furnishes the teachers for the broadcast programs, and deals directly with local school systems in providing monitors and organizing the study groups to whom the broadcasts are directed.

These are patterns which have demonstrated their ability to work successfully. It should not be assumed, however, that the basic problem of shared control is an easy one to solve. One example I have recently seen is in a country where the Ministry of Education is allowed to use certain daytime hours on the national station which is supported by commercial entertainment in the evening. The time is given rather grudgingly, and accepted not entirely gratefully. The government originally argued that educational services would justify the expense of bringing in television. But the educational authorities have little money to put behind the programs, and the television station feels that it should spend as little as possible on this "unproductive" daytime broadcasting. Scheduling has often proved difficult, and technical support has often been unavailable. Until recently, there has been no maintenance service for school receivers, and almost no contact between the producers of the programs and the teachers expected to use them. Some high officials, at the beginning, felt that educational television would be important to the country. Once the station was established, and the operational control delegated, then the responsibility fell between agencies, and neither one felt able or willing to put the necessary resources behind it.

Every observer who has studied the use of the mass media for educational and developmental purposes has been impressed by this problem of shared control and responsibility. It is one of the leading causes of inefficiency in the use of the media, and of suspicion and resistance toward the entire system. In general, nothing makes so much difference in working out this problem as the attitude of the responsible official who stands over both the teaching and the broadcasting services. If the chief of government backs instructional television with sufficient energy, or if there is sufficient belief in it at high political levels, or if it falls within a single ministry -- then cooperation comes very much easier. For example, in Samoa, the Governor of the islands committed himself to introducing ITV, put the necessary funds behind it, and gave the director of education full responsibility for it. After a first bit of resistance from a few traditionally oriented educational advisers, there has been no real problem in Samoa of conflict between television people and school people. Similarly, in Thailand where the schools have their broadcasting station, the service has developed smoothly.

In Colombia, there were actually two false starts on ITV, one of which failed because of a financial crisis, the other because a change of government swept out the chief supporter of television for teaching. On the third try, both top support and finances were strong, and the system grew and prospered.

The Key Relationship in the System

If control and organization are favorable, then, the entire outlook for system functioning is more favorable. But the key relationship still remains a problem -- the fact that a small number of central production personnel must work with a large number of distant teachers and school officials, and if this relationship is not cooperative then the whole system will be ineffective. How does an ITV system go about solving this problem?

This responsibility, too, rests basically on management. Almost the first requirement is the establishment of needs and goals for the system. I am not talking about the general function of such a system. This, as we have said, is to share teaching and demonstrations which will become a part of the learning activities within classrooms or other study groups. Rather, I am talking about the establishment of felt needs for instructional television. If no such urgent needs are felt, then the prognosis is very poor indeed. The country we mentioned, where ITV was in trouble, was one where there was a generalized feeling at the beginning that instructional television would be useful. However, when the responsibility for the system was delegated to lower echelons, this general feeling was never made specific. What high priority educational problems are there which can be solved with the aid of television better than by other means? Are these the problems to work on first? Are they sufficiently urgent to justify the use of scarce resources on a television system? If questions like these can be fully considered, and convincingly answered, then it will become much easier to establish the necessary cooperative relationships within the system. This requires a review of the special needs of education against both the national goals and the special needs of other parts of the development program. That should be the first order of business.

A second problem on the desk of top management is only a little less important. It [illegible] to establish the part television is to play within education. How is the responsibility for teaching to be divided between the studio teacher and the classroom teacher? Is ITV to be supplementary to classroom teaching, to be used when the classroom teacher wishes to use it; or is it to be a basic part of the course, to be scheduled and made use of regularly? In Samoa, in Colombia, in Hagerstown, in many of the states within Africa and Latin America where it has been used for specific and felt needs, it is a basic part of the course. The studio teacher and the classroom teacher work together almost like a teaching team. In the typical U.S. suburban school system, in much of Western Europe, and in some former colonial states which have picked up this pattern, it tends to be supplementary. Obviously, it is much more difficult to work out a team-teaching relationship of this kind than merely to provide a supplementary service to be used when desired. On the other hand, when highly qualified teachers or good demonstrations are in short supply, then it seems a waste of television to use it daily for supplementary services. In the Republic of the Niger, for example, where three years ago there were only 66 fully qualified teachers in the entire country and little chance of getting more, it would have made little sense to opt for supplementary television. It made more sense to share the best qualified teachers by television in as many classrooms as possible. This meant that television had to be a basic part of the courses, and the expert teacher in the studio and the less experienced teacher in the classroom had to learn to work together.

How is this accomplished? Experience with these systems has been that in most of them it is neglected, but that where it is done well it has been by means of involving the classroom teachers in the planning and preparation, and by providing them guidance and in-service training.

In a relatively small system, like that of Samoa, it was possible to bring a high proportion of the classroom teachers into planning workshops, the summer before ITV started, to work with curriculum consultants, studio teachers, producer-directors, supervisors, and school officials on what should be taught on television and what kinds of activities should be planned around the television in the classroom. Perhaps these native classroom teachers were not the world's greatest curriculum consultants, but they provided a context of practicality and a knowledge of the students that was essential, and furthermore they learned by doing: By working on the problem of what should be taught, and how it should be taught, they came to understand a great deal more about television teaching, and their relationship to it. Needless to say, they also got rid of most of the suspicion with which they first approached the new-fangled method.

In Colombia, where the number of teachers was so much greater, it was impossible to have all classroom teachers in planning workshops, and so the Peace Corps utilization volunteers, and some counterparts provided from the Colombian government, became key parts of in-service training. They answered questions, and even showed the classroom teachers how to conduct a good classroom drill or discussion based on a televised lesson. Most of the teachers in Colombia as in many other developing countries have been accustomed to teaching by rote memory, or at least to sticking very close to a syllabus and in effect requiring students to learn the syllabus. Being exposed to a different kind of teaching in their classrooms by television is therefore a powerful learning experience, as well as a traumatic challenge to their own teaching methods. For this reason, a maximum of guidance, especially early in the use of ITV, is helpful. Most such ITV systems furnish detailed teacher guides, and most of them use the television, after school hours, for direct in-service teacher training, pointed toward utilizing the televised teaching to come. In Samoa, the principal at each school, freed of some of his curriculum and scheduling problems, became a kind of teacher supervisor, meeting with his classroom teachers and helping them to adjust to the new ways of doing things.

Finally, it is essential in an ITV system to have feedback from the classrooms to the studios. If for no other reason, it would be justified in that it permits classroom teachers to continue to feel involved in the program. But it is of much greater practical importance. Except in cases when the studio teacher can pre-record his program and visit a school during the broadcast, he really has very little idea how his teaching is being received. Television teaching is blind teaching. Even if students are brought into the studio as surrogates for the classroom audience, they are unlikely to be fully representative. Therefore, the reports from the classroom, visits by the teacher, visits by members of the field staff, workshops and summer courses -- all must be used to maintain contact and cooperation.

Outputs and Inputs

The ITV system is a productive one, and the multiplicative power of its distribution system is truly remarkable. The approximately 100 people working on production in Samoa turn out an average of 61.25 hours of class time per week. Of these, 53.5 hours are produced locally during the year; the remainder (7.75 hours) are from the previous year's recordings. These 53 hours of local programming require about 180 hours of studio time, counting set-up and rehearsals. In addition to school classes, the Samoa station broadcasts also an average of four hours each evening for adults, so that it turns out about 85 hours a week.

Through the power of television to multiply central production, the students of Samoa receive about 70,000 student-hours of televised teaching a week. This is a multiplicative factor of over 1000. In a country like Colombia, the multiplier for every hour of broadcast instruction may easily be 50,000. In other words, 10 hours of ITV per week would be turned into half a million student hours.

It is fascinating to think that satellite ITV might have a multiplicative power of a million or more, but equally sobering to think of the difficulties of trying to establish the studio-classroom relationships in that kind of situation.

Of course, broadcasts are not the only output of the production unit in an ITV system. In Samoa, an average of ten sheets of mimeographed or printed paper per student per day go to the classrooms -- more than 12 million a year. These are guidance to the teacher, reading and study materials for the pupils, practice exercises and tests. The flow of materials back from the classroom is considerably less, but, even so, there is supposed to be one report on each course from each classroom teacher, in addition to oral reports from school officials and visitors from the central office.

Unit costs of an instructional television system chiefly reflect economies of scale. For example, the cost per student hour (including operation and amortized capital investment) of the Samoa system is a little over 50 cents. As we have said, however, the

Samoa system is a very large production and distribution plant, serving a relatively small number of students. Hagerstown, which serves two and one half times as many students as Samoa, can deliver television for about 20 cents per student hour. Colombia, which is an order of magnitude larger than Hagerstown, can deliver televised class lessons for less than 5 cents per student hour.

If an ITV system builds its own facilities, it can count on an investment of anywhere from a quarter of a million to two million dollars (which is what it cost Samoa for six open-circuit channels). A rule of thumb in this country is that capital costs will be somewhere in the neighborhood of two or three times the annual operating cost.

How are costs distributed among parts of the system? Here are capital and operating allocation for three developing states:

Capital Investments

	Production	Distribution	Reception
Colombia	52%	25%	17%
American Samoa	52	43	5
Arequipa, Peru	66	0	34

Current Costs

	Production	Distribution	Reception
Colombia	32%	42%	26%
American Samoa	64	31	5
Arequipa, Peru	56	20	24

The figures just given do not include the salaries of classroom teachers, or other school officials. Consequently, reception costs are largely costs of receivers and antennas, and keeping them working, and of field staff. They do not separate out management or feedback costs. Therefore, they represent the allocations to the three main units of the television part of the system only. Arequipa, obviously, has no capital investment in distribution, because it rents time on a commercial station. Both Arequipa and Samoa serve small audiences, and therefore their production costs tend to be relatively greater than the cost of distribution.

What might the allocation of costs be for an ITV satellite? There are so many different configurations possible for satellite television that any estimate at this point will be fantasy. For example, direct broadcasting or rebroadcast through ground stations, one channel or several, very large audiences for each program or a fragmented schedule of coverage -- all these will affect the distribution of costs. But we can get some idea of the way satellite costs might look from the experience of Midwest Airborne Television, which has been covering about 250,000 square miles of the American middle west with ITV broadcasts from an airplane. A very large part of these costs have gone into procuring, fitting, and operating the airplanes, as these figures show:

	Production	Distribution	Reception
MPATI, Capital	8%	63%	29%
MPATI, Current	6	68	26

We can guess -- and it is only a guess -- that both the production and distribution percentages for a satellite system would be lower than for MPATI, that the chief capital cost might very well be for receiving sets, and that the capital allocations might read something like 3% -- 25% -- 72%. The current operating cost has been guessed at something like 20% -- 40% -- 40%, but this is sheer science fiction until we get the more specific figures that should be available to us in a few months. Even from these very rough figures, however, we can see that a very large share of both the investment and the non-hardware problems with a satellite system are going to lie in the area of reception and use.

We have said nothing as yet about the chief output of the system -- the amount learned by those who use it. Do students learn from instructional television?

Students learn a great deal from instructional television. Hundreds of studies now attest to this fact. Some of the results are quite spectacular. They learn in elementary, secondary school, and college. They learn in the preschool years and the years of adult education. They learn in developing countries as well as advanced countries. They learn so many different kinds of subject matter that it is difficult to identify any kind of course to which television, well used, cannot make some contribution.

If we ask whether they learn as well from television as from face-to-face teaching, the results are muddier because it is so difficult to design a meaningful scientific experiment around that question.

Every one of the experiments that have been designed carefully enough to control all the variables except the method of delivering the same teaching (by television or face-to-face) have concluded that there is no significant difference related to the use or non-use of television. Most of the media-comparison experiments designed less scientifically (but sometimes more realistically) have also shown no significant differences between ITV and face-to-face teaching, and when there has been a difference it has more often been in favor of television.

There can hardly be a lingering reasonable doubt, after the number of studies that have been made, that television can be an efficient instrument of teaching. I said, can be. Not necessarily, will be. That depends on how it is used -- what kind of teaching is put through it, how much motivation the students have, how the television is worked into the full learning experience. But the basic question can now be considered to be answered: Television can handle effectively any part of the teaching-learning process it can carry. It cannot conduct a discussion efficiently, nor can it provide much individual counseling. But what it can do, it can do well. We can confidently expect it to carry its weight in a well-designed teaching-learning system.

Preparing and Introducing the Non-Hardware Components

The critical year of an ITV system is generally the first one. The modal judgment of the system during that year is likely to be that the hardware, after some pre-testing, works beautifully, and the instructional services are "disappointing". This is because a great deal of time and effort are expended in selecting proved hardware components, installing them, and testing them, whereas if the preparation of programs begins in the summer before the system goes on the air, that is about as much time as the non-hardware components are felt to deserve.

It may be instructive, therefore, to go over some of the preparations that need to be made before the non-hardware components of an ITV system are ready to operate with the same efficiency as the hardware. Needless to say, it would be very difficult to find a system that has been brought into existence with this much forethought, but if we think of getting ready for satellite ITV, with its enormous costs, large human requirements, and wide publicity, then we can hardly avoid behaving responsibly about preparations for it.

We can divide these preparatory activities in such a way as to illustrate the functions of different parts of the system.

Management

-- The needs for different kinds of televised content must be reviewed against national goals, special needs of school and adult education, and special needs of other parts of the development program. This review should be made with the aid and concurrence of high level policy makers from relevant agencies of government.

-- Basic decisions must then be made as to how broadcast time and channels are to be allocated to different uses, taking into account other commitments on broadcast time.

-- Decisions must be made on a time schedule by which the services of the system are to be developed over geography, educational levels, and a spectrum of needs. What are the priorities? Measured against practical considerations, when can they be met?

-- Funds must be obtained, budgets tentatively allocated, personnel hired and procedures established to control expenditures.

-- Second echelon supervisors must be selected, and with their advice tables of organization must be set up, and plans made for hiring and training.

-- Basic decisions must be made on the part television is to play within education. How is the responsibility for instruction to be divided between the studio and the classroom teacher? Is ITV to be supplementary or basic? This kind of decision will require the advice of educators and experts on instruction by television.

-- In consultation with production personnel and prospective users, a schedule for the television week must be made.

Production

-- At the outset, it is necessary to decide, within policy determined by top management and in consultation with representatives of the users, what services and courses are to be offered.

-- Against a review of available resources, decisions must be made as to what courses and materials are to be produced locally, and which ones can and should be obtained elsewhere.

-- The form of teaching must be decided in detail, and also what the classroom teacher will be asked to do in connection with it. Obviously, this will take the advice of ITV experts and classroom experts.

-- Studio teachers must be selected. If some of them need training, that must be provided. Also, the rest of the production staff must be hired and/or trained.

-- The content, outline, and timing of each course must be determined in detail. This will probably require for each course a planning and working committee including studio teachers, classroom teachers, producers, and content specialists. This committee must try to make sure that the latest and best in content and method are represented. (There will never be a better time for a curriculum review!)

-- Studio teachers, with the assistance of producers, writers, artists, and so forth, must adapt and fill in these outlines to fit their own styles. Scripts must be prepared, and art work, props, and studio sets specified.

-- Pilot programs should be prepared, critically viewed, and, if possible, tested on the kind of audience they are supposed to teach.

-- Programs may be recorded and stockpiled in advance of going on the air.

-- Supplementary materials -- texts, suggested readings and activity lists, tests, practice materials, teachers guides -- will have to be prepared, reviewed, and duplicated.

-- Programs from other sources must be ordered, reviewed, and scheduled.

Distribution

-- The technical management of the station must see that the facilities are being constructed according to plan and schedule.

-- Technical employees must be hired and/or trained.

-- The technical staff must have sufficient practice with the equipment to be able to operate it smoothly.

Reception and Use

-- As many classroom teachers as possible must be involved in planning and preparation. Many of them can probably help in planning courses. Others can work on classroom activities to fit the courses.

-- They must be consulted and given as much responsibility as they can take for deciding upon the part of the teaching that is to be done by the classroom teacher.

-- It will probably be necessary to select and train a field staff of utilization advisers to work with classroom teachers when the broadcasts start.

-- One or more workshops may profitably be scheduled for these classroom teachers.

-- Plans must be made for prompt maintenance of receiving sets. This may include traveling maintenance technicians, with replacement sets for use when the classroom set has to be taken to the shop for repairs.

Feedback

-- Forms must be prepared for comments from the classroom teachers.

-- If research is to be a part of the feedback plan, then one or more research men must be hired, and given a chance to get acquainted with the system and make plans for some baseline measurements.

Obviously, this implies a great deal of hard work on the part of a great many people. A considerable amount of training will probably be necessary: Therefore, we are talking about a period of several years. Without some such period of planning and preparation, however, the non-hardware components of the system will not be ready to function well at the outset, if ever.

These are some of the non-hardware components of an instructional television system: people, most of whom must have special training and ability; sufficient financial input to operate the whole system, not merely the hardware; a series of special relationships among the people in different parts of the system, particularly those in the studios and those in the schools; a workable pattern of organization; programs, supplementary materials, utilization assistance, in-service training, feedback information; and a period of enlightened planning and preparation.

If there were no hardware, of course, then the great multiplicative power of the system would be lost. But without these non-hardware components, even the best hardware would be dead metal and plastic. And to the extent that the non-hardware elements are inadequate, the system will fall short of its bright potential.

Working Paper No. 2

CONSIDERATIONS IN DECIDING WHETHER AND HOW TO INTRODUCE AN EDUCATIONAL SATELLITE

by Wilbur Schramm

Let us suppose, on our part, that we have the kind of basic information described in Paper 2; or, if we take the viewpoint of the leaders of a developing country, let us assume that they have reviewed their goals, needs, and resources. Then what questions must be considered in deciding whether, under given conditions, it is feasible and desirable to introduce a communication satellite into the system of education and development?

1. How useful will television be?

We can assume that the chief product to be delivered by such a communication satellite will be television. The kind of satellites we are talking about can, of course, deliver radio, telephone, telegraph, teletype, and any other kind of electronic signal. But if the use of television cannot be justified, then it is extremely doubtful that the cost of a satellite in a developing country can be justified for these other services alone.

The essential contribution of television to education and development is to deliver excellent teaching and demonstrations simultaneously over a broad area. Therefore, the top priority needs of the country for education and information must be viewed against the possibility of being able to share widely the best in teaching and demonstrations. Would this ability make a really substantial contribution to meeting the needs? These are some of the indicators to look for:

Is there a serious shortage of teachers?

Is there a shortage of adequately educated or trained teachers?

Is there a shortage of teachers or materials for specialized courses?

Is there a shortage of teacher aids in the classroom?

Is there a need to expand the school system more swiftly than teachers can be fully trained for the job?

Is there a need to furnish a model for present classroom teachers?

Is there an urgency to upgrade the quality of education without waiting the length of time it will take to train new teachers and bring them into the schools in sufficient number?

Is there a need of better demonstrations, better audio-visual support, for the adult programs?

Is there a need to share the truly expert community development advisers more widely?

Is there a need to expand horizons, and plant the seeds of aspiration and change?

To any of these, and similar needs, television, used wisely, could contribute significantly, as it has already proved its ability to do in Colombia, Samoa, Niger, the Ivory Coast, and many economically advanced countries.

But it is necessary to ask certain doubting questions. For example, could the need be met more easily or effectively by the use of films? Film is cheaper than television when used for a relatively small number of schools, and can be delivered reasonably well over short distances if roads and transportation are good. It has certain advantages over television in that a film can be stopped for discussion, or repeated for emphasis. But large areas and difficult travel call for television. And film, because of its relative inflexibility to changes and the need to serve one school at a time with one copy, pretty well limits the use of audio-visual materials to supplementary experiences rather than direct teaching.

Could the job be done adequately by radio? Radio is cheaper -- perhaps one fourth to one fifth the cost of television -- but it lacks the ability to bring visual experiences along with sound. Schools prefer television if possible.

Is there time to train a new generation of teachers? It will be cheaper to improve teacher training than to introduce television, but television will have an impact at once, whereas the impact of improved teacher training will be delayed and gradual.

It is well to be aware of hidden traps and hidden bonuses if television is introduced. For example, how much would the vivid common experience with television contribute to unifying a country? Would it possibly contribute to solving the national language problem, if there is one? Would it not provide in-service training, by example, for classroom teachers? Would not the large and dramatic technology of television have a considerable impact on breathing the spirit of change and modernization into the whole school system and the development field program? On the other hand, would it tend to undermine efforts to raise the quality of the classroom teacher? Would it be unduly resisted? Would it perhaps encourage dissatisfaction by showing disadvantaged people how other people live? What other possible effects might lurk beneath the surface?

2. How useful would a satellite be?

If it is determined that television could contribute more satisfactorily than other means to solving some of the most urgent and irksome problems of a country, then it is necessary to consider whether a satellite is the most desirable way to deliver television.

Essentially a communication satellite is a transmitter that receives signals from the ground and relays them to an area 100 times or more as large as can be served by a ground-based television station. Its characteristics, therefore, are a very large area of coverage and a central point of transmission -- which implies a certain centrality of programming. It is possible, of course, to receive signals from more than one ground station, to share the time of transmission, or to have several channels in the satellite and share those. But the more the service of a satellite is fragmented and divided over its coverage area, the less advantage a satellite retains over ground-based stations. Whatever configuration is finally decided upon, therefore, there is likely to be more sharing of common programs than would be the case if the same area were served by 100 local stations.

It is consequently necessary to consider questions like these:

Can the satellite and its programs be designed to serve adequately the different language groups in the country?

Can the satellite and its programs be designed so as to serve adequately the different cultural groups in the country?

Can it be so designed and managed as to serve adequately the needs of the different school systems, the different curricula, schedules, ability levels, etc.? The essence of education is localness; the essence of a satellite is very wide coverage -- can these two characteristics work together?

Can it be so designed and managed as to serve adequately the different agricultural areas of the country? In India, for example, there are usually said to be 86 of these. The dry farmer needs different advice from that needed by the wet farmer; the rice farmer has different needs from the wheat farmer; the fisherman needs different help from that needed by the stockman; and so forth. Offhand, it would seem that a diverse agriculture would need many local stations rather than one satellite. Therefore, the information needs of agriculture need to be matched up against the capabilities of space communication.

Ideally, a satellite seems to call for a large, densely populated country. Suppose that the country is not large enough to use all of the signal, and it spills over the borders -- as it will in the case of most countries. Are the political realities such that insuperable difficulties would lie in the way of sharing the satellite with neighboring countries, or that insufferable objections would arise from neighbors?

On the other hand, what might be some of the hidden bonuses from sharing so much informational experience nation-wide? Would it contribute to integrating the country, helping to solve the language problems, bringing lagging school systems up to the level of others? Could not the extra time and capacity of the satellite be used to speed the growth of telecommunications -- telephone, telegraph, teletype, etc. -- with immense effect on business and other aspects of society? But once again, might it be dangerous to trust most telecommunication services to a single satellite? If it went suddenly out of service, not only national television but also long-lines communication might be dark for weeks or months.

What are the alternatives? If interconnection is desirable at all, then it can be managed by the exchange of videotapes, or by installing microwave or long lines between stations. The first of these is perfectly feasible; indeed, until recently, the noncommercial stations in the United States "bicycled" their programs around the circuit by mailing tapes. It was slow. It lost all the advantages of timeliness, and the impact of a network speaking together. And the efficient postal service and air transportation of the United States might be more reliable than the internal transport of some developing countries. In the United States the lag between the first and the last station using a videotaped program was of the order of six weeks. Even this would be difficult for an educational system, where all the schools begin at about the same time, and want the first television program when they begin -- not six weeks later.

Microwave and long-lines connections would eliminate the delay, but they appear to be considerably more expensive than satellite telecommunications. This raises the questions of costs and resources, which we must take up next.

3. Are the resources adequate?

If it is decided that television could contribute in an important way to meeting one of the top national needs, and if it can be demonstrated that satellites per se appear to be the best way to deliver that television, then we must consider the demands and requirements of satellite television, and the resources available to meet them.

The needs are for money, for personnel, and for a technical base. This is not the place to discuss the costs of a satellite system, but we must do so, in our reports, somewhat more sharply than anyone has so far done -- particularly the cost of the system apart from the space link. The space link -- the satellite itself, and possibly some of the ground station hardware that goes with it -- is the part of the system most likely to be contributed from outside. It is, however, likely to be only one fifth to one tenth the cost of providing television receivers. With these latter costs, there is some hope of getting partial aid from outside the country, bilaterally or from an international agency. Essentially, however, there will be an overpowering need to manufacture receivers within the country, or to find an unusually favorable arrangement for importing them. It is entirely possible, however, that the financial feasibility of the system may turn on the ability of the country to meet the annual operating cost of maintaining, programming, and utilizing the system.

This is what killed Airborne Television in the United States. That organization received a grant that bought its airplanes and their transmitters, and for a while helped to finance its annual operations. When the grant ran out, and times got harder, however, the program budget was cut to about one tenth what was thought to be needed -- quality of programs was sacrificed to keep the system working at all. The result was that the airborne system in its entirety will go out of existence this May.

It will be quite important, therefore, for us to have something to say about the probable annual costs of maintaining a satellite television system at a level of quality that permits it to do what it was intended to do.

The second requirement is for personnel. There is no doubt that almost any developing country able to consider satellite television at all will be able to produce the trained personnel necessary to run it. But not instantly. The need and time for training are constantly underestimated by most new entrants into this field. Here again, therefore, we must be quite specific. What are the numbers and kinds of trained people that will be required? Given the local conditions, which ones can be trained in the country, and which ones must go abroad? What experts must be imported to participate in the training? My observation has been that the necessary time for collecting a trained staff has usually been underestimated by about one half. Anything we can do to make clear the personnel needs will therefore be useful.

Finally, there must be a technical base. Most countries have some base in electronics. They have some technical schools, turn out some radios, have some repair technicians. And if they put in a satellite system, they are likely to find themselves moving toward an electronics industry that would greatly increase their industrial potential. The obvious place for such an industry to start is with the manufacture of receiving sets -- transistorized if possible -- and with the training of maintenance and operating personnel. The extension of power lines would immensely help television, and would be stimulated by the introduction of television. Once a system like satellite television picks up momentum, the technical base will grow with it. But in the beginning the pump must be primed.

The needs of the country must therefore be weighed against the resources of the country. Inasmuch as the resources will never be adequate for all the needs, it is necessary to weigh the cost and benefit of meeting other needs and those of meeting the needs which satellite television is designed to serve. For example, how does one compare the desirability of investing in satellite television with that of investing in steel mills, or roads, or railroads? These are not easy decisions, and will depend to some extent on the image of economic and social development held by the leaders and on their picture of political reality.

If it is judged that the resources are not presently adequate to make satellite television possible, along with other high priority investments, then it does not necessarily mean that the answer must be negative. Rather, if the idea is a good one at all, the decision is rather to postpone than to decline -- to slow the timing, and perhaps not to jump into the satellite age at once, but rather to move in slowly through extending ground television. But we should do all we can to be sure that a developing country does not commit itself to an enterprise like the one we are talking about without realizing clearly what resources will be required. There has been some tendency on the part of developing countries to think of satellite television as a possible gift. This is far from the truth. However the space link is provided, a large national commitment will be required.

4. How should the system be designed?

By this time, it will be apparent that there is a certain advantage in beginning with the problem rather than with the hardware.

If a developing country is presented a satellite, ready-made, the design of that instrument will, to a considerable extent, determine the use to be made of it. For example, does it provide for direct broadcasting to relatively small and inexpensive receiving units in schools and villages, or only for rebroadcasting through ground stations? This should be mainly a policy and program decision: It is necessary to weigh the advantage of a certain amount of local programming for local needs against the ability to reach all the remote areas in one long jump.

Does it provide one channel or more? Does it provide for extra-voice channels to handle language services? Does it have sufficient capacity to make possible telecommunications service apart from television? These, too, are program and policy decisions.

The mere appearance of the satellite represents a policy decision of great importance -- a decision to jump into the space age rather than moving at a measured pace into it by extending ground television first, building up a solid base of experience and a corps of trained people -- and, needless to say, a communication system that would continue to function even if something happened to the satellite. There is no answer to a problem like this that applies to all countries. Rather it depends on the local conditions and on the national image of its future. There may well be good reason to vault over the intervening stages and put the whole country into the space age at once: Otherwise, it might be years before television reaches the remote villages. On the other hand, it might be prudent -- financially, educationally, politically -- to move more slowly. The most practical policy might be a compromise, involving a period of preparation and then a combination of direct broadcasting and rebroadcasting through ground stations.

The point I am making is that satellite technology is more flexible than the needs and conditions under which a developing country must operate. The design of the space link can more easily fit the needs and conditions than vice versa. But if the needs and conditions are not controlling, then the uses of the system are to some extent frozen by the technology. This is manifestly unsound and undesirable.

5. How should the system be organized and managed?

There are only incomplete precedents for organizing and managing such a large and complex communication system as we are talking about. Because of the size and complexity of the operation, it is important to consider the requirements of organization and management early in the planning.

From the precedents of national television systems in developing countries, we can derive at least the lesson that every effort should be made to avoid crippling conflict between the agencies responsible for different parts of it. The history of instructional television is all too full of conflict between ministries of education (which control the schools) and ministries of information (which control the facilities). In our own country there is often incomplete cooperation between community-owned educational stations and the school systems which make some use of the daytime broadcast hours. It sometimes works better when the school system (as in Hagerstown or Denver) or the ministry of education (as in Thai radio) has its own facilities. But we are talking about a national facility, which will serve many ministries. Agriculture clearly must have a part in it, along with education (for the schools), information (for the general audience programs), health (for the community health programs), and so forth. Each of these must be responsible for what kind of service goes to its own constituencies. Therefore, within the framework and tradition of the government concerned, some pattern, some organization, must be evolved to insure that the needs of all these constituencies and the responsibilities of all the agencies involved are served. Whether the pattern will be that of the Institute of Television in Colombia, the BBC in Britain, Radiodiffusion Télévision Française, or something else, is immaterial: The point is, it needs to be the subject of careful consideration in the country where it is going to work.

There is even less precedent for an organization to control and manage an international satellite, such as we might expect to see serving Latin America. There are a few international organizations that exchange television programs, like Eurovision, but they mostly share sports events and cultural programs which are a great deal less sensitive than school programs and a great deal less local in their application than services to agriculture and community development. An international satellite would probably require a certain amount of sharing of time between countries and a certain number of shared programs. The provisions for sharing and the nature of the controlling organization would have to be determined by rather delicate negotiations which would not succeed unless there were a general wish to share. Yet if this amount of sharing could be satisfactorily brought about it would be a good omen for future relations among the countries concerned.

One other international aspect of such a satellite deserves attention early in the process. This is the problem of signals that spill over national borders into countries that are not involved in control of the satellite. This would not be much of a problem if it were not possible to pick up signals on home or village receivers directly from the satellite. It may not be so much of a problem anyway: A great deal of ground-based television today can be received across national borders, and in some cases (for example, Israel and her Arab neighbors) under conditions of considerable international tension. Nevertheless, this problem is something that must be considered, and it might have an implication both for design of the system and for preliminary negotiations. For example, all of East Pakistan would obviously come within the coverage area of an Indian satellite, unless the beam were so restricted as to eliminate all of northeastern India. The beam would doubtless cover Nepal, and fall on part of the territory of China. If there were severe objection to this, most particularly if there were retaliation by jamming or attempting to affect the positioning or functioning of the satellite, would the matter be adjudicable under international or space law, or would it be treated as an act of war? No implication is intended that such problems are insoluble: merely that it would be well to consider them before, rather than after, the fact.

6. Planning for the introduction and use of the system

If we can assume that the basic questions have been decided, and that there is need for a satellite to advance education and development, that adequate resources can be provided, that the technical shape of the system will reflect the national needs for the system and the conditions under which it will be used, and that problems of management and shared control can be solved, then comes a time when the country must plan in great detail how to move into the satellite age.

The lesson we have learned from observing the introduction of television into developing countries is that the hardware is planned, specified, and tested most carefully, but that the planning of the software is mostly neglected. This is partly because the towers and transmitters and studios are so dramatic, and because the financing of them represents such an effort on the part of the country. It is partly because the task of hiring, training, programming, preparing the schools and the field staff, is invariably underestimated. If previous experience with television means anything, a country that wants to prepare adequately to use an educational and development satellite must allot two to three years to the task. That length of time is a minimum estimate.

Moving into the educational satellite age is a major national activity for any developing country. It will require a national plan, expressed in terms of goals, timing, activities, and commitment of resources. A considerable number of people will have to sit down at least three years before the anticipated S-Day, and plan, as carefully as they would make a battle plan, for such considerations as these:

Uses and priorities -- Viewed against national needs and goals, what educational levels and what educational subjects deserve first attention? What adult skills, understandings, or attitudes get first priority? If the service is not to be introduced everywhere at once, what schools, what parts of the country should get it before others? On what schedule should the service be broadened geographically, and extended over additional programs and school subjects? What proportion of the time should be devoted to general audience programming? What proportion to telecommunication services?

Content of the services -- If there is to be general audience programming, what kinds and levels of entertainment or information programming does the country want? Against the national goals, how can the content of the school programs be made to serve those goals and mesh with the rest of the development programs? For example, if the priority needs are for technical or vocational understanding, are the school programs directed to those objectives? There will never be a better time to review curriculum and method! Does the content of the education to be broadcast truly represent the latest and best in knowledge? Does it represent the latest and best in method and approach? For example, this is an opportunity to decide whether the "new math" or new approaches to science or language teaching should be introduced. It is a time to review what is happening in the classroom and what should be happening there -- in other words, an opportunity such as may never recur, to re-examine national education in its most basic aspects.

Personnel needs -- How many skilled people of what kinds -- engineers and technicians, studio teachers, producers, field staff personnel, and others -- will be needed? How many of these are available? Can the others be trained or must they be imported? Where can training best be done? Will it be necessary to bring in some expert advisers or trainers to speed the process of training and smooth the introduction of the new system? How much time will be required -- when should the various types of training begin in order to have qualified people when they are needed?

Preparation of classroom teachers and field workers -- How can classroom teachers, supervisors, principals, field advisers, village-level workers, and others who will be at the receiving end of the television, best be involved in the planning and preparation, so that they can contribute their experience, understand what is required of them, and develop cooperative attitudes toward the system? What in-service training will classroom teachers or field workers require in order to make efficient use of television? What time requirements are involved -- when must the workshops or seminars or training sessions begin? And who will be needed to conduct them?

Preparation of programs -- What programs, satisfactory to the country's needs, can be obtained ready for use, and what programs w have to be made? What programs will have to be made locally to fit local needs? What people (studio teachers, producers, classroom teachers, supervisors, subject matter experts, television experts, and others) must be brought together to plan the programs? How can this activity be organized so that the labor is divided and time is used efficiently, and at the same time the maximum number of classroom and field personnel are made to feel involved? When will this process have to start? How can a few pilot programs, at least, be tested before an entire series is made? How many programs should be stockpiled in advance? How much program material -- for example, film clips of local development activities or regional cultural activities -- should be stockpiled for later use? What visual aids should be provided in advance for studio teachers?

Supplementary materials -- What materials must be provided to classrooms or study groups, to accompany the television teaching? There will probably be need of teacher guides; there may also be need of text materials, practice and test materials, experimental props, instructional brochures. How many of these will be needed at the beginning of a year or a term, and how many must be provided at intervals throughout the term? The magnitude of this need can be illustrated by the case of American Samoa, which furnishes about 12 million sheets of mimeographed supplementary materials per year, for only 8,000 students.

Links to the classroom and the field program -- What delivery service will be required to get these supplementary materials to the classroom or the village when they are needed? What kind and amount of continuing advice and direction will classroom teachers and field workers need in order to utilize the television broadcasts efficiently? How many and what kind of field supervisors will be needed for this purpose? How many and what kind of maintenance men will be required in order to keep receiving sets in repair? What kind of transportation will these maintenance men and other field staff require? How can feedback -- suggestions, comments, critiques -- best be obtained from the classrooms and the field for the guidance of studio teachers? What evaluation forms and what research personnel and arrangements will be needed?

Timing and scheduling -- from the kinds of planning activities we have been suggesting, a rough time schedule will begin to emerge. At certain lengths of time before the system is to go on the air, certain training must begin, certain trained personnel must be available, certain activities must start and certain work must be completed. Consequently, at each of these times, certain resources must be committed. At a given time before S-Day, certain management personnel must be functioning, certain hiring must have been completed, certain training must be under way, certain activities in review of curriculum and preparation of programs must be at a specified stage, certain materials must have been acquired, there must be housing for persons, activities, and equipment, and the operating budget must be at a certain level. Gradually, from all of this, the operating organization the television schedule, and the materials that constitute the real contribution of the system, will emerge.

Such planning and preparation itself is a complex activity. We have not meant to suggest that all the planning must be done by the same people. Obviously, it cannot and should not. It should be coordinated by the same person or persons, but the people who decide on the uses and priorities will, for the most part, not be those who review the curriculum and decide on the content of the services; and there probably will be minimum overlaps between this latter group and those who actually plan and prepare the programs. A great many different persons and groups will be involved. But it will be a long, a complex -- and a highly essential -- activity. Most developing countries have been content to muddle into television, and to find their way to effective educational programming and use after the system has begun to function for general entertainment. Sometimes they have succeeded, sometimes not. Given a satellite system, devoted mainly to education and development, my guess is that they can hardly afford the risk and the luxury of trying to muddle into it.

4-19-68

Working Paper No. 3

FILM VERSUS TELEVISION IN EDUCATION

by Robert F. Schenkkan

The use of film instead of television for educational purposes is attractive for a number of reasons. The scheduling flexibility of film appears to make it more responsive, if not to individual learning rates, at least to local learning levels. The ability to stop the film in the classroom, comment on a portion of it, and then proceed is not possible with television* and is clearly a great advantage to the competent, prepared teacher. Both film and television are visual media, but film provides a higher degree of picture clarity and definition. It is not difficult to substitute color film for black and white, where appropriate; to do so in television requires a huge increase in receiver investment. Color is credited with a great deal of power to increase interest and, by inference, to advance learning. Certainly for subjects such as art, color appears to be extremely important.

A country's national identification easily can be placed on each reel of film, thus obviating some of the difficulties that are bound to arise in using educational programs of an international nature. A national language or local dialect can even be dubbed on the sound track, although this requires specialized facilities. These possibilities would help to give programming more of a national character. Thus, by setting up major film libraries, it might be possible to obviate many of the very real complexities that would arise from the international nature of a satellite-delivered television program in Latin America.

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* It is not possible unless a video tape recorder is being used in the classroom.

Why not then, use film instead of television? A response to this question might begin with the observation that film has been used in education for 40 years or so. However, there is no public school system anywhere in the world that relies on film for a major portion of its instructional offerings, whereas television is extensively employed by several systems. Although educational film is used in many organizations, such as the military, nowhere is it the core of the educational process, as television is, for example, in Samoa. Moreover, nowhere is film credited with the kind of reshaping and reform of education that should be the major purpose of any large scale technological innovation.

It is not necessary to delve into complex theories to find reasons for this startling difference in the effect of the two visual media, nor is it necessary to resort to elaborate economic analyses to find the differences between the two, but some examination of economics is in order.

The significant economic differences between the two media do not occur at the production level, surprising as this may seem. It is true that documentary film costs average $1,000 per minute, as compared with television costs of less than $100 per minute. But these differences are not really very great when one spreads the per-minute cost over audiences of millions. If, for example, a potential educational audience of 10 million is assumed (a very modest number for a satellite-distributed educational program covering all of Latin America), film production costs could be estimated at .0003 cents per viewer per 30-minute film, while television production costs would be only .00003 cents.

The advantage of television over film lies in distribution economies. If it is assumed that: (1) the audience numbers 10 million; (2) this audience is divided into classrooms of 40 students each; and (3) it is possible to use each film print 100 times* within the two- or three-week period that the subject topic fits the curriculum, then 2,500 prints of each film would be required, at a cost of $20 each for a 20-minute film. (This is the lowest possible estimate and is based on the economy of great numbers.) The cost per subject topic would then be $50,000. For example, if a 30-week course with three lessons a week is assumed, the cost of prints alone would be $4.5 million. An attempt to multiply this by 12 grades in six subjects produces a staggering total of $324 million. Furthermore, with reasonable handling, each print is only good for approximately 200 showings.

Based on the initial projection of 100 showings per print per year, the entire stock would need to be replaced every other year. Maintaining and shipping the above-described film stock at the most efficient possible level (using Indiana University Audio Visual Center figures) would require one man-hour per 70 minutes of film, or a full-time staff of 200.

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* This film utilization would be especially difficult in urban Latin American areas and would obviously be impossible in rural areas, where schools often consist of only two rooms and rarely of more than five or six.

A further disadvantage of films in education is that no economies could be realized from an increase in the size of the audience. Instead, an expansion from 10 million student viewers to 20 million student viewers would result in a doubling of the entire film-print cost every two years.

Economics, however, is not the only reason for rejecting film as a substitute for ETV. When educational practices at the classroom and the administrative levels in underdeveloped countries are examined, one cannot help but be struck by the potential offered by a large scale ETV system.

In developing countries, classrooms are commonly badly managed. The teacher of 30 to 40 children, although usually provided with a standard curriculum, has neither the knowledge nor the management skill necessary to progress at the rate that the curriculum demands and at the same time motivate the students to seek solutions for themselves, question, and develop creatively.

Ministries of education in developing countries tend to be overwhelmed by the sheer magnitude of their problems in housekeeping, payroll, budgets, personnel, and teachers' working conditions and benefits. Therefore, while curriculum revision and technological innovation may be deeply desired, there is usually no time or energy left to introduce them.

Finally, as weak as these systems appear in the classroom and at the ministry center, they are usually weakest at the point where administration and classroom are presumed to meet, that is, at the level of supervision. Communication between the administrative center and the schools is minimal and frequently nonexistent.

Television can make a significant difference in helping to overcome weaknesses found in developing countries. In the classroom, obviously, it can assist the teacher in pacing his class, a basic inadequacy of classroom-managed instructional films. Television, in itself, is an innovation in the classroom. Well-programmed, it is capable of guiding teachers and motivating students to genuine learning experiences. As one experienced observer said of his Colombian school visits, "It became easy to tell that a school had television before one ever saw the set, because one could tell that education was taking place."

At the administrative level, large scale introduction of ETV requires study and revision of curriculum by an established deadline. These revisions are necessary before ETV can be instituted. At the supervisory level, the nature of the television system requires that a system of two-way communication to the field be developed, if only to provide the teacher with the teachers' guides and the administration with an evaluation of the utility and pacing of the programs being broadcast.

It is the distribution system in ETV that inspires these changes. The teacher needs only to turn a knob to get the material desired. Compared with handling a projector, sorting through innumerable cans of film to find the right one, darkening the room, and so forth, television is simple indeed. While television may at first appear to be a threat to the teacher and his status, he soon comes to rely on its service.

If an ETV system is to operate at all, the educational administration must provide set maintenance, teachers' guides, and feedback to all parts of the television coverage area for which it is responsible. Again, this responsibility is imposed by the mode of distribution in ETV. The local option to use or not use instructional films in each classroom provides no corresponding management imperative.

Broadcast television programs require the strengthening of educational supervision and administration at a single central point but greatly simplify the job of quality teaching in thousands of classrooms where faculty preparation is minimal. Instructional films, on the other hand, require a high degree of teacher competence in each classroom. Therefore, films, even when available, tend to be little used, while television lightens the burden of the classroom teacher and improves the quality of teaching.

Working Paper No. 4

TECHNICAL CONSIDERATIONS OF SATELLITE COMMUNICATION SYSTEMS FOR EDUCATION

by Bogdan R. Stack

Introduction

The rapid development of satellite technology during the past decade offers new and exciting possibilities in the area of communications and information transfer. The application of this new technology to ETV is of particular interest, especially in geographical areas where terrestrial communication facilities are either nonexistent or poorly developed.

There exists, however, a tendency to emphasize the advantages of such applications and to de-emphasize the many problems that are inherently associated with the introduction of any new satellite service. Although these problems may not always be of immediate concern, their implications must be understood and taken into account by all who plan to utilize satellite systems.

The four categories of factors associated with ETV by satellite that are discussed in this paper are:

1. International coordination
2. Operational considerations
3. Distribution system requirements
4. Technical feasibility considerations

It is assumed that the value of television as an educational tool has already been demonstrated and that this working paper is concerned only with the problems associated with the establishment of a system that will deliver television signals from the originating stations to the students' place of instruction.

International Coordination Requirements

The Treaty on Peaceful Uses of Outer Space, which was ratified by a majority of countries, states that outer space "is not subject to national appropriation." Thus, a synchronous satellite in geostationary orbit occupies a permanent position in an international domain and therefore requires close coordination among those who also have an interest in using the same segment of outer space. In addition, because all satellites radiate electromagnetic energy, internationally regulated radio frequency assignments must be utilized to prevent potential interference.

Both of these items, that is, "parking slots" in stationary orbits and the available frequency spectrum, constitute limited international resources and must therefore be used rationally and efficiently throughout the world.

To prevent interference between various systems, ITU (International Telecommunications Union) has for many years been engaged in developing and recommending technical standards and guidelines that are, in general, observed by all nations. Coordination procedures in such matters as the allocation of frequency spectrum, limitations on power radiated by terrestrial transmitters, and so forth, have been established and have been successful in preventing interference.

The advent of satellites has created a serious possibility of interference between terrestrial systems and satellite systems that operate at the same frequencies. To combat this difficulty, there was developed, under the auspices of CCIR,* a regulation limiting the maximum allowable power flux density (watts per square meter) that can be radiated from satellites. At the same time, to accommodate wide band systems, another regulation was adopted that limited the maximum allowable power flux density that can be radiated in any 4-kHz bandwidth (watts/square meter/4 kc). These regulations are shown in Table 1, below.

Table 1

POWER FLUX DENSITY LIMITS FOR ALL ANGLES OF ARRIVAL
AT THE EARTH'S SURFACE
(EARC Regulations 470 O AND 470 P)

System	Maximum Allowable Power Flux Density (dBW/m^2)	Maximum Allowable Spectral Flux Density (dBW/m^2/4kHz/s)
System using wide-deviation FM	-130	-149
Other system	Not specified	-152

Note that these limits represent total power flux densities from all satellites illuminating the same area.

Because these requirements are not fully satisfactory from the technical viewpoint, CCIR has recently recommended that these three numbers be replaced by a single requirement that would limit the permissible power density in any 4 kHz bandwidth, taking into account the angle of arrival of flux (θ). The following limit was proposed:

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* CCIR (The International Radio Consultative Committee) is part of ITU.

$$\text{Maximum power flux spectral density} = \left(-152 + \frac{\theta}{15}\right) \text{dBW/m}^2\text{/4 kHz}$$

However, since regulations deriving from international convention can be changed only by subsequent conventions, this recommendation currently has no legal standing. It is nevertheless accepted generally as being more realistic than previous ones. It represents a constraint on satellite ERP (Effective Radiated Power) and RF bandwidth, as shown in Figure 1.

These regulations have been developed to prevent interference with terrestrial microwave systems and are applicable to those frequency bands that are shared between terrestrial and space services. At this time, only the 4-6 GHz band is allocated to both space and terrestrial communications, but as the services are expanded, limitations on satellite power flux density will have to be extended to cover any new frequency bands that may be shared by terrestrial and space systems. No allocation has been made as yet to allow the transmission of television signals from space at UHF. If standard procedures are followed, a lengthy investigation of potential interference problems would precede the granting of any such allocation. In the process of such an investigation, new limitations on satellite power may well be established. Thus, although transmission at UHF is discussed in connection with satellite television, it is not known what, if any, the ultimate restrictions on such operations will have to be. It is quite possible that, because of potential interference problems with existing terrestrial systems, space broadcasting at UHF will never be authorized.

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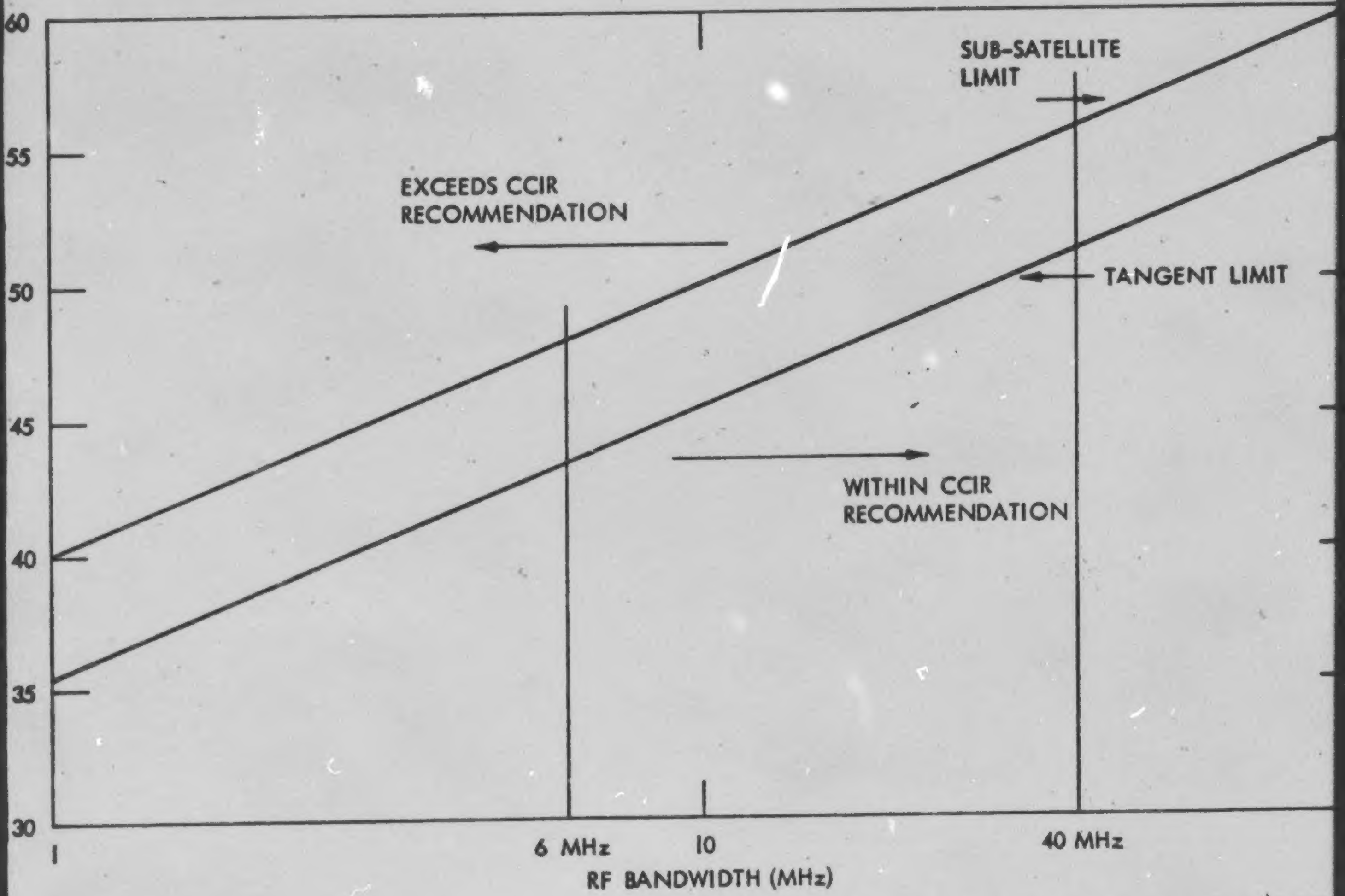
FIGURE I

RECOMMENDED LIMITS ON SATELLITE ERP AS A FUNCTION OF BANDWIDTH



The second international resource that may have to be regulated at some future date is the number of parking slots in stationary orbits. Since interference between systems can result from the proximity of one satellite to another, it is necessary to separate the satellites in orbit sufficiently, so that only one satellite is in the antenna beam of the ground station at one time. With existing systems equipped with large antennas, a separation of 4 to 6 degrees appears practical. As a result, only a limited number of "parking slots" exists. As satellite systems increase in number, some form of international coordination will become necessary to prevent possible interference. This problem is discussed in more detail in Appendix A, where it is shown that the spacing of satellites varies inversely with the size of ground antennas and the frequency of operation. Thus, large ground antennas and high frequencies result in more parking slots in any one section of an equatorial orbit.

The combination of available frequency spectrums and the total number of satellites in orbit (that can operate without interference) establishes a limit on the total number of television channels that can be made available in any given area.

It appears that, at least for the next decade, the problem of interference will not be excessive because of the restricted number of systems that are anticipated. As a result, political rather than technical considerations constitute a primary limitation on the introduction of such systems. Accordingly, should the United States establish a satellite system, the operating characteristics of which are not presently covered by international regulations, it should probably commit itself to changing the system to conform to any future international regulations that may be agreed upon. The degree of such commitment, particularly in cases of systems established for underdeveloped nations, represents a policy decision that must be taken before the decision to proceed, since it may require additional investment in the system at some later date.

The following conclusions can be drawn regarding international regulation of satellite systems for ETV:

- At this time, international regulations exist concerning the maximum allowable power that can be radiated from satellites to prevent interference with terrestrial systems operating in the same frequency band. These regulations are considered too restrictive, and a new limitation on total power per unit bandwidth has been proposed; however it has, as yet, no formal regulatory status.
- These regulations apply only to the shared frequency bands that have been authorized for space use (4-6 GHz).
- Transmission from space at UHF is not presently authorized. Lengthy proceedings would be required to obtain such authorization, and it is possible that such authorization would not be forthcoming.
- It is not known what limitations on satellite power would be necessary to prevent interference between space and terrestrial systems that would share common frequency bands other than those presently authorized. Extensive studies of interference problems will be required before such limitations are established.

- No regulations now exist concerning the problem of the in-orbit parking slot. However, it is recognized by all interested parties that new international regulations are required to prevent ultimate chaos and interference between systems. There has been some concern that preemption of parking slots by nations capable of launching satellites will not conform to a spirit of international cooperation unless such nations are prepared to modify their systems to conform to any new regulations that may be developed in the future.
- New regulations are expected to be developed in the areas of: (1) procedures establishing right-of-first-occupancy of a place in orbit, and (2) constraints on authorizations for space broadcasting in frequency bands other than those currently authorized.

Operational Considerations

System Availability

It is recognized that the complexity of the technology required to establish and operate satellite systems in synchronous orbit is such that only two countries possess this capability today. Any nation establishing a satellite system must depend on the United States or the USSR to launch its satellites into orbit and to replace them when they fail. Thus, until and unless some international agency is created that will guarantee launching capability when required, dependence on the major powers will continue to exist. Because of this, there may exist a certain degree of reluctance to use the satellite for vital national communication functions without the availability of alternative means of communications. The possibility of unavailability of satellites in orbit must be always kept in mind, and the relative importance of such "down-time" must be realized. In Appendix B, the basic problem of time delays involved in replacement of satellites in orbit is briefly considered. It is shown that such delays may vary from six weeks to 24 months, depending on circumstances.

System Maintenance Requirements

It must also be remembered that operation and maintenance of a satellite system requires a certain degree of technical sophistication that may not be available in emerging nations. The receiving installations that, for this study, include television sets, antennas, and possibly conversion equipment, must be properly installed and maintained. With the tendency toward reducing the cost of the hardware, the probability of failure or malfunction of equipment is increased. In tropical areas, experience shows that maintenance of electronic gear presents a serious problem.

In addition, television receivers and other receiving equipment require a stable source of power to operate properly. Although voltage and frequency stability of power sources are taken for granted in advanced countries, they may be difficult to achieve in remote areas. As a result, the quality of the television picture may suffer. The storage of space parts (particularly the inexpensive ones) represents another problem because of their sensitivity to humidity and temperature.

Keeping a receiving installation in proper working condition requires the services of trained repairmen. When such repairmen are not available when needed, and when one cannot easily obtain replacement parts, the usefulness of television as an educational tool will begin to suffer. Even installations that operate continuously but are out of adjustment may be too bothersome to the student and the teacher to be effective.

Accordingly, to make ETV fully effective, it is necessary that required spare parts and a sufficient number of appropriately trained technicians be available locally.

Satellite Control

A satellite in stationary orbit will not remain "parked," but will drift under the influence of the gravitational forces of the sun and the moon and the irregularities of earth's shape. It is necessary, therefore, to monitor and occasionally adjust its position in orbit and its performance. A satellite-control earth station is therefore required. Whoever operates such a station is therefore in complete control of the system and is capable of disabling the system at will. When one satellite serves several countries, this consideration may require special agreements between participating nations. The satellite-control facility may be colocated with the transmitting station. In this case, the operator of this station has full control, not only over the satellite, but also over the content of the material being transmitted. The potential for misuse of this capability for propaganda purposes is apparent.

Jamming and Intentional Take-Over of Satellites In Orbit

Unless very sophisticated (and costly) transmission techniques are used (which are not considered feasible for ETV application), there is nothing that could prevent a determined jammer from disabling the system. Similarly, it is quite possible to take over the satellite by superimposing an unwanted transmission of sufficient power. These possibilities emphasize the general vulnerability of satellite systems to determined interference and the necessity for international cooperation in these areas.

Distribution System Considerations

Methods of Distribution of Television Signals to the User

Direct Broadcast. Direct broadcast is a technique by which the television signal reaches the receiving antenna of the user directly. Since conventional television systems operate at frequencies in the VHF and UHF bands and utilize VSB-AM (Vestigial Side Band-Amplitude Modulation), convertors may be required if broadcasting is accomplished at another frequency or utilizes FM. Direct broadcasting can be accomplished in the following ways:

- Compatible frequency and modulation techniques (VHF-VSB/AM): since the transmitted television signal matches the parameters of the television receiver, no conversion equipment is necessary at the receiver.
- Compatible frequency-incompatible modulation (UHF-FM): conversion from FM to AM is required at the receiver.
- Incompatible frequency and modulation (microwave-FM): frequency conversion from microwave to UHF is required in addition to FM to AM conversion.

Rebroadcast. Rebroadcast is a technique that utilizes an intermediate facility that receives the original signals from the transmitter and retransmits or redistributes them to the users. Rebroadcast can be accomplished at any frequency utilizing any modulation technique. Necessary signal conversion is performed at the intermediate station.

General Discussion

Direct Broadcast. This service consists of delivering television signals directly to the user's receiving installation,which will normally consist of a rooftop antenna and a minimal amount of additional equipment. Such service provides a direct link between the satellite transmitter and the user's receiver. Local terrestrial television transmitters and distribution networks are not required. Because of the lack of local television broadcasting stations, it would be difficult to include programming of local interest, low cost local advertising, and so forth, and it would be difficult to encourage the development of local industry associated with broadcasting operations. The lack of local coverage and autonomy in broadcasting has been stressed by many people as being potentially undesirable because of centralization of information dissemination in the hands of a national broadcasting entity. Even with the best of intentions, the geographical distance to the transmitter may preclude inclusion of local material at reasonable cost.

Thus, the first major objection to direct broadcasting that has been voiced is the fact that, because of the nature of the direct broadcast service by satellite, the entity that controls the satellite in orbit and the transmitting and station-keeping earth terminals will have a virtual monopoly over the control of broadcasted material.

The second major objection to direct broadcasting by satellite is the problem of system reliability, which is discussed in some detail in Appendix B. In essence, it is feared that direct broadcast service will prevent development of terrestrial communication links (primarily because the cost of satellite systems would preempt all available funds). The tendency will be, therefore, to use the satellite for as many other services as possible (including telephony). Should satellites fail and for any reason be difficult to replace, the overall communication capability over long distances would be substantially impaired because of the lack of a properly developed terrestrial network. The problem associated with satellite failures is discussed in Appendix B. The reader can draw his own conclusions regarding the gravity of this problem.

A consideration in favor of direct broadcasting is the fact that it represents the most economical means of reaching a large number of users and could be accomplished at a relatively low cost to the user. This is of particular interest in countries where dispersal of the population and difficult terrain make terrestrial networks difficult to implement. The technical factors associated with the feasibility of such service are discussed later in this paper.

Technical Feasibility Considerations

Television Picture Quality Requirements

Appendix C includes a summary of television picture quality requirements and operating frequency allocations applicable to terrestrial television service. It is normally assumed that an SNR (signal-noise ratio) of approximately 40 dB should be used as a design objective.

Future Capability of Active Satellite Systems

Data supplied by Comsat Corporation was used to determine the ERP that may be available from stationary satellites in the near future.

Table 2, below, shows the ERP that may be obtainable with solar cell technology by the mid-1970s. Satellites of different weights are considered, and the type of booster required to lift this weight into stationary orbit is shown. The applicable cost items estimated by Comsat Corporation are also shown for comparative purposes.

Table 2

ERP FROM SATELLITE (4° BEAMWIDTH) THAT MAY BE EXPECTED
WITH SOLAR CELL TECHNOLOGY BY 1972
(Dollars in Millions)

		ERP (4° Beam)					
Time Frame	Useful Orbital Weight (Pounds)	At UHF 800 MHz (dBW)	At SHF 4 GHz (dBW)	Cost of R&D	Satellite* Unit Cost	Launch Cost	Cost per Launch
1969-1972	1,000	62	61	$27.4	$ 5.1	$ 7.9	$13.0
	2,000	67	64	35.0	9.0	15.0	24.0
	4,000	69	67	50.0	14.2	15.0	29.2
1972-1975	1,000	62	61	27.4	5.1	4.4	9.5
	2,000	67	64	38.5	9.1	15.0	24.1
	4,000	69	67	45.0	14.0	15.0	29.0
	8,000	72	70	62.6	18.3	25.0	43.3
	20,000	76	74	77.0	27.4	60.0	87.4

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* Includes apogee motor cost, where applicable.

Source: Based on data developed by Comsat Corporation.

Comparing these estimates of ERP at 4 GHz with CCIR limitations shown in Figure 1, it becomes apparent that the power capability of satellites will soon be substantially higher than the limits imposed by consideration of interference with terrestrial systems. A similar situation will probably exist in any other shared frequency band. Accordingly, a decision to proceed with the required research and development must take into account the possibility that such satellites could be used only when no terrestrial systems operating on the same frequency bands exist.

The realization of the ERP shown in Table 2 is dependent on satisfactory progress in developing space-qualified designs for power amplifiers and large size space erectable antennas and on solving all problems related to high power operation in space. Although no new technical breakthroughs are required, the degree of effort presently being expended on developing such space-qualified designs may not be sufficient to meet the dates indicated.

Manufacturers contacted on this subject have indicated that little incentive exists for industry to expend their own research and development funds. NASA appears to be the only agency continuing research in the areas mentioned above at a level of effort sufficient to develop flight-qualified designs by 1972. Opinions as to the adequacy of existing NASA programs vary quite widely. Thus, availability of the ERP shown above depends on several years of sustained research and development effort. Accordingly, in spite of the optimistic prognostications reflected in the ERP figures shown in Table 2, caution is recommended in assuming that they will be available as anticipated. Although the research and development conducted by NASA will undoubtedly solve the basic technical problems, a large amount of engineering will be required to produce flight-qualified satellites and the boosters required to launch them.

It appears that this effort can be accomplished only if sponsored by the U.S. government, since demand for such satellites would not justify in-house research and development by aerospace firms.

If it is desired to operate at frequencies above 8 GHz, additional research and development and engineering effort would be needed, since no flight-qualified satellites operating at these frequencies have been built.

The conclusion to be reached from these comments is that although technically feasible, satellites permitting direct broadcast to users will not be available until several years after a research and development contract for developing these satellites is placed with an aerospace company.

Satellite systems operating at frequencies other than presently authorized (4-6 GHz), and especially those operating at frequencies above 10 GHz, would require an even larger period of research and development and flight qualification. Because of this, it is the belief of the writer that any countries outside of the United States and USSR that desire to establish their own domestic television satellite systems in the early 1970s will stay within the existing state of the art, that is, a frequency modulation in the 4-6 GHz range and ERPs in the range of 45 dBW (4° beamwidth at 4 GHz). Because such a system requires receiver antenna sizes on the order of 15-20 ft, it is more oriented towards rebroadcast rather than direct broadcast. Any other choice requires additional research and development that might delay the implementation of the service and would necessitate operation in frequency bands that are not presently authorized for space use.

Technical Feasibility of Various Distribution Techniques

The various techniques of distributing television signals that were defined earlier are discussed in more detail below.

Direct Compatible Broadcast to the User (UHF-VSB)

User Installation Consisting of a Conventional Television Receiver

This method requires the transmission of amplitude-modulated VSB (vestigial side band) signals at the VHF or UHF frequencies directly to the user's television receiver, which is equipped with an indoor antenna. No modifications are required to the user's installation, and consequently this technique would yield the lowest receiver cost. However, to meet television quality requirements (listed in Appendix C) the ERP radiated from the satellite would have to exceed the present and forseeable state of the art, and the cost of the satellite and the required booster would be prohibitive.

If existing and proposed regulations concerning prevention of co-channel interference in shared frequency bands were applicable to the UHF band, all would be violated by this system. In addition, severe restriction of the total number of orbital space positions would be a consequence of the sensitivity of this system to interference (see Appendix A).

It can be concluded that this system should not be considered for ETV because it is not feasible either from the technical or operational standpoint in the forseeable future.

User Installation Equipped With an Outdoor Antenna and Low Noise Preamplifier

Ground Segment Considerations. A substantial reduction in the ERP required from the satellite can be achieved if a high gain antenna and an antenna-mounted preamplifier are utilized. The gain of the antenna (G) and the noise temperature of the system (T) determine the sensitivity (G/T) of the receiving installation. The G/T can then be traded off against the required ERP from the satellite. This trade-off is shown in Figure 2. Maximum limits on ERP imposed by existing CCIR regulation (which are not currently applicable to the UHF band) are also shown, as are the ERP that is expected to be available by 1972 (assuming 4° beamwidth and a 4,000-lb satellite).

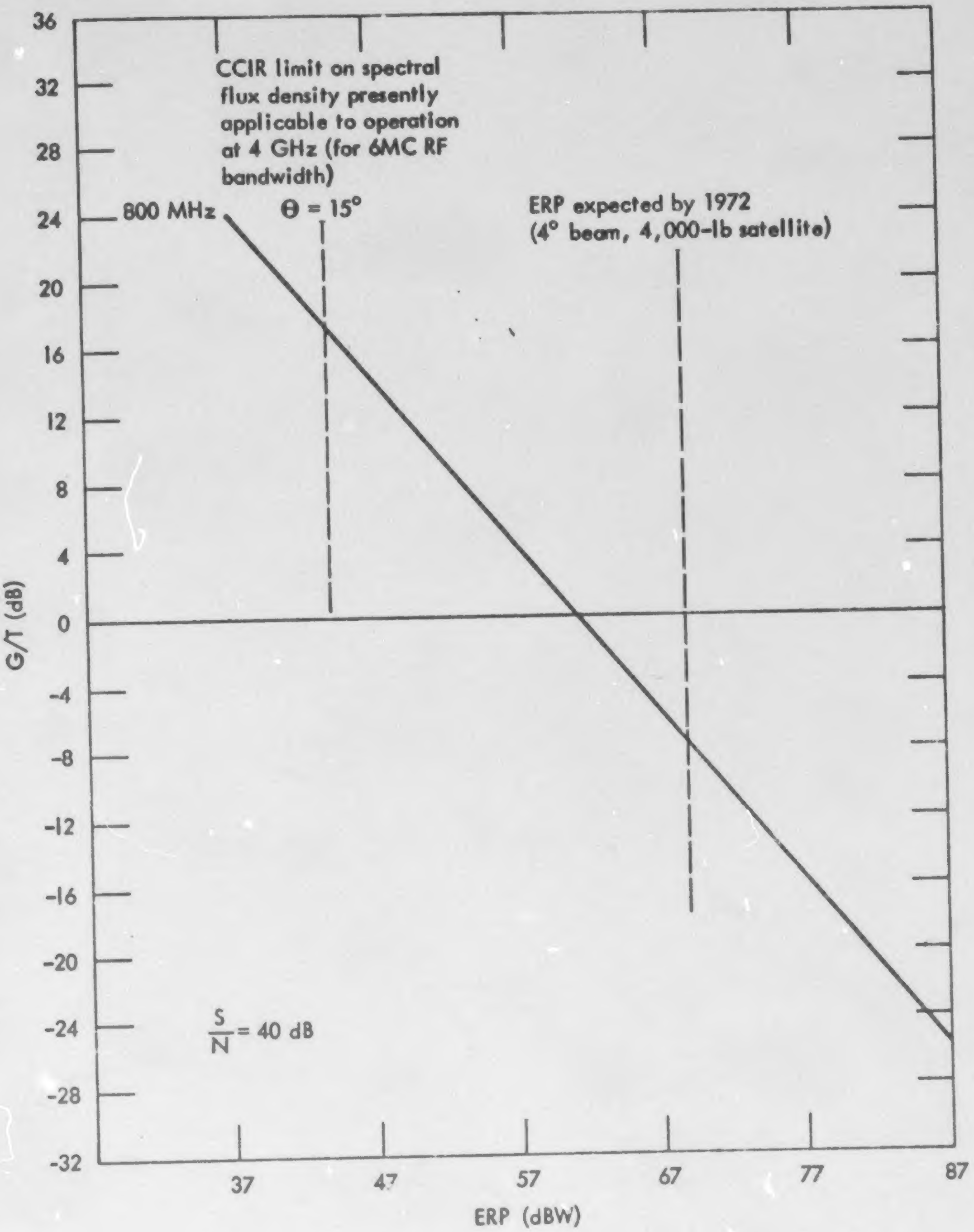
It can be seen from Figure 2 that with satellite ERPs of 45 dB, a high sensitivity receiving installation (G/T approximately 15 dB) would be required, with attendant high cost and large antenna size. It appears, therefore, that to achieve a reasonable cost for the ground receivers, high ERPs from satellites are needed. Because of possible interference problems with terrestrial television broadcasting on the same frequencies, the use of this technique may encounter serious opposition.

Space Segment Considerations. To provide a coverage of approximately two million square miles, the beamwidth of the parabolic antenna on the satellite would have to be approximately 4°. At upper UHF, this requires an antenna of approximately 20 ft in diameter with a gain of approximately 32 dB.

If a more restricted area of earth coverage is desired, the antenna diameter will increase progressively (coverage of 500,000 square

FIGURE 2

G/T VERSUS ERP FOR VESTIGIAL SIDEBAND MODULATION



miles requires an antenna approximately 40 ft in diameter). NASA is currently developing a 30-ft antenna that can be unfurled in space. This effort constitutes the major ongoing program, and future possibilities will depend on how well it will succeed. Thus, although not presently available, such satellites may be developed, if sufficiently aggressive research and development programs are pursued.

International Agreements. The use of UHF for direct broadcast would necessitate new international agreements in several important areas. Some of these may be listed as follows:*

- Allocation of UHF band to broadcasting from space.
- Amendment of existing regulations to permit radiation of larger power flux from satellites in the UHF band.
- Resolution of problems that may arise because of technical impossibility, at the present time, of limiting the coverage of a DBS to the frontier of one country.
- Resolution of potential co-channel interference problems that could result from two similar systems operating in adjacent areas.
- Need for some degree of international cooperation, in view of the possibility of intentional interference.

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* Based on items discussed during the meeting of representatives of regional broadcasting unions in Paris, January 1968. (Reported in Telecommunications Journal, March 15, 1968.)

The length of time required to negotiate a proper international framework in which space broadcasting could be effective is unpredictable. However, judging by the many factors concerned and the complexities of the problem, it could be substantial. Yet, in the writer's opinion, such international agreements are necessary if ultimate chaos is to be prevented.

It can be concluded that:

- Direct compatible broadcast at UHF to a user's receiver equipped with an outdoor antenna and preamplifier is currently outside the state of the art. It could become feasible in the mid-1970s, provided vigorous research and development programs are continued and successfully completed.
- To make such systems economically attractive,large amounts of power would have to be radiated from the satellite. This would create a possibility of unacceptable interference with terrestrial systems and would require establishment of international regulations and standards.
- Total number of orbital space positions for satellites would be severely restricted because of interference considerations.
- UHF spectrum would have to be allocated for space services.
- Lengthy proceedings would be needed to arrive at international agreements concerning all these problems,and it is quite probable that authorization for UHF broadcasting from satellites would never be granted.

Frequency-Modulated Broadcast at Compatible Frequencies (UHF-FM)

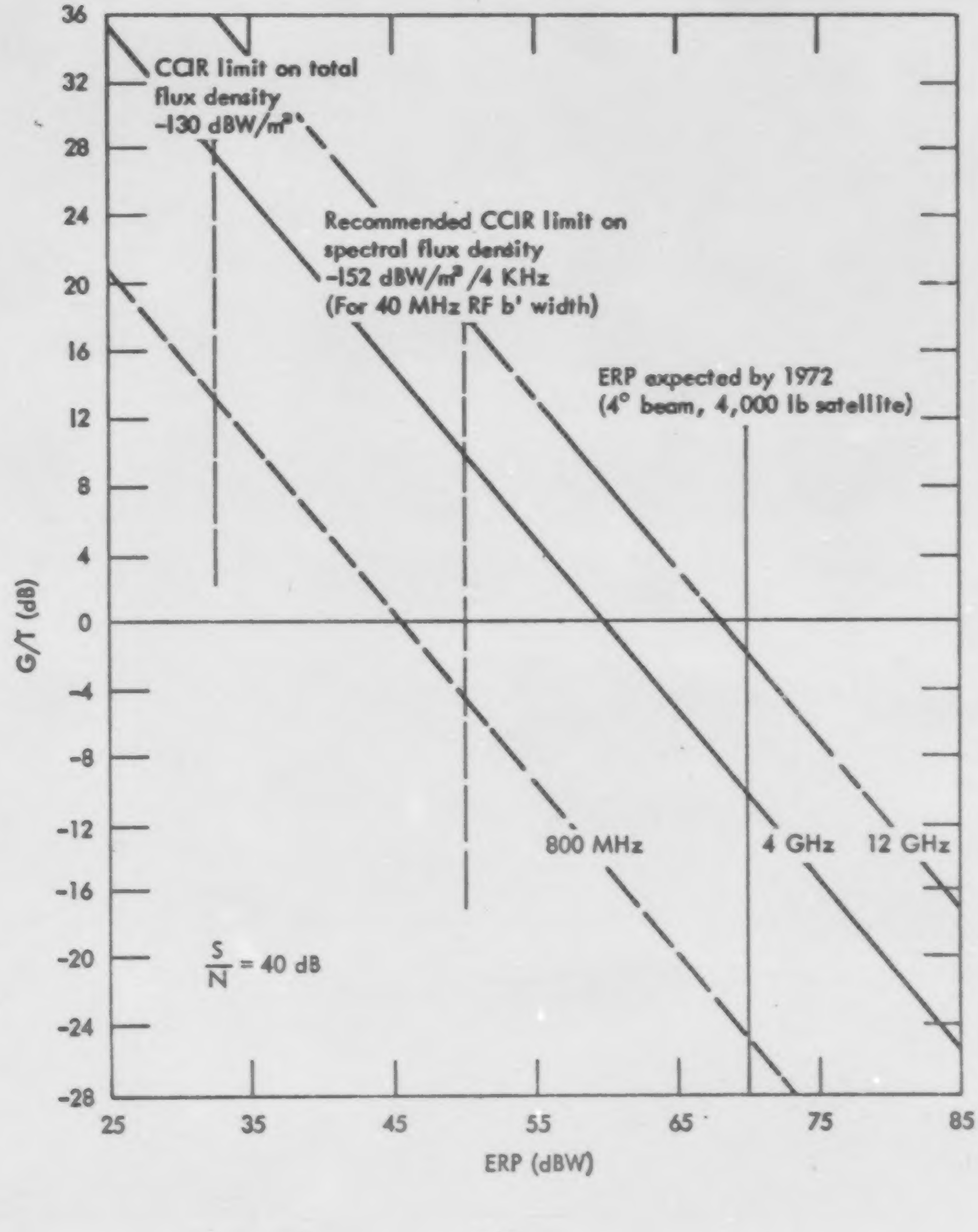
Ground Segment Considerations. This method utilizes frequency modulation operating at compatible UHF frequencies. As a result, wider bandwidth is required (by a factor of up to 5:1) over the amplitude modulated case (AM/VSB).

The receiver installation requires an addition to FM-AM converter and now consists of the outdoor antenna, preamplifier, and converter (FM demodulator). The benefits derived from the use of FM, however, compensate for additional components required at the receiver. Because of the lower sensitivity to noise, substantial reduction in received signal power is possible. The trade-off between the G/T of the ground receiver and the ERP from the satellite is shown in Figure 3. Comparison with the amplitude modulated case in Figure 2 shows that a reduction of approximately 16 dB in required ERP can be accomplished for similar G/T. Accordingly, it appears that satisfactory operation could be obtained with moderate amounts of ERP from satellites. This is accomplished, however, at the cost of the substantially wider RF bandwidths required by FM. It is not clear at this time what restrictions on this method of operation would be imposed by the study of potential interference problems. This technique is also applicable to local rebroadcasting of the television signals received from the satellite to home receivers by a standard television broadcasting station.

Space Segment Considerations. Since the size of the antenna is determined by the desired areas coverage, all comments made in the previous section (AM case) regarding the satellite are also applicable here.

FIGURE 3

G/T VERSUS ERP FOR FREQUENCY MODULATION



Total Number of Channels. Because of higher immunity to interference, the number of orbital space positions would be substantially increased over the AM case. However, the substantially higher RF bandwidth per channel required for FM would limit the number of different frequency channels that can be accommodated by one satellite.

International Agreements. All points mentioned in the preceding section (AM case) are also applicable here.

It can be concluded that:

- Because of its increased immunity to interference and the resulting relaxation on required receiver sensitivity (G/T) or satellite ERP, this method appears more desirable than the AM case. It also appears to be the most economical at UHF. The space segment, however, is still beyond the state of the art in terms of space-qualified designs. If research and development to produce such designs is completed, the satellites could be operational by the mid-1970s.
- Co-channel interference problems and the possibility of intentional interference require thorough evaluation and may necessitate international agreements, as previously discussed.

In summary, the techniques of direct broadcast to the user at UHF, utilizing either AM or FM, are at this time outside the state of the art if receiver costs are to be kept small. The implementation of these techniques requires completion of additional research and development to obtain space-qualified designs. Therefore, a substantial investment in research and development is necessary before direct broadcast satellites can be made operational. If such an investment is made immediately, the consensus seems to be that a direct broadcast system can be made available in 1975. It is doubtful, however, whether new international agreements and standards that would be required for such services could be negotiated within a comparable time period.

Frequency Modulated Broadcast at Microwave Frequencies (Microwave-FM)

Ground Segment Considerations. This technique is now universally used for satellite communications. For television broadcast, the ground installation would require an antenna, preamplifier, frequency converter, FM demodulator and a television set.

Space Segment Considerations. Since the space segment frequency and method of modulation are compatible with existing techniques used by INTELSAT, combined communication and television service could be provided through independent transponders in the satellite. However, because the operating frequency bands may be shared with terrestrial communication systems, CCIR regulations on spectral flux densities must be observed. Figure 4 shows the trade-offs between G/T and satellite ERP at 4 MHz. All technical requirements are considered to be within the state of the art. Since the existing communications satellite experience is at this frequency, development costs would be lower than for techniques previously discussed.

Because of the necessity of meeting the CCIR requirements, the maximum ERP from satellites would be restricted to approximately 50-55 dBW, with a corresponding requirement for G/T of approximately 10 dB. To keep costs reasonable, ground antennas of approximately 8 ft minimum may be required. Thus, this method is particularly suited to relay broadcasting, whereby television signals are received by a centrally located ground receiver equipped with an antenna of reasonable size (20 ft) and then relayed to rebroadcasting stations by terrestrial microwave.

International Agreements. If operated within the INTELSAT System, no new agreements would be necessary. If operated outside INTELSAT, some coordination and cooperation would be needed to prevent mutual interference.

Rebroadcast

As previously discussed, rebroadcast implies a retransmission of signals by an intermediate broadcast. Accordingly, any one of the techniques described above for the transmission of signals between the satellite and the receiving antenna could be used. However, because of technical and operational advantages, the frequency modulation at microwave frequencies (microwave-FM) is universally used for rebroadcasting. This technique was described above.

Operation at Frequencies Above 4 GHz

Several proposals have recently been made to provide television service from satellites at frequencies between 10 and 40 GHz. Operation at these frequencies is characterized by the increase in receiver and external noise, increases in losses caused by adverse weather, and higher atmospheric losses. In addition, generation of high RF power at these frequencies still presents problems. These disadvantages, however, are partially offset by larger antenna gains and especially by the fact that new operating frequency allocations are badly needed.

Generation of sufficient ERP to ensure satisfactory direct broadcast operation at these frequencies may be difficult and costly in terms of today's state of the art, but the rapid progress of technology in this area might render such service economically feasible in the near future. A sustained and substantial research and development program that is oriented towards development of space-qualified hardware would be necessary; however, such a program has as yet not been instituted.

On the basis of the technical and operational arguments discussed above and in the appendixes, it appears that rebroadcasting at 4 GHz by satellite would represent a more advantageous solution than direct broadcasting, for the following reasons:

- Technically, the system is feasible today and could be implemented without substantial delay or research and development expenses.
- It would prevent the "all eggs in one basket" situation by permitting the development of local terrestrial facilities.
- It would create less confusion in case of satellite failure (because of the availability of local communication facilities).
- It would prevent complete monopoly on the dissemination of program material.
- It would permit sufficient flexibility for future system changes.
- It does not require any new regulations or standards.

General Conclusions

Table 3 summarizes some pertinent considerations associated with various methods of television signal distribution. It shows that only rebroadcast at 4-GHz frequencies utilizing FM is feasible at the present time from the technical and regulatory standpoint.

Satellite capability required for economical direct broadcast may become available within four to seven years, provided research and development effort specifically oriented towards that end is maintained and successfully completed.

New international standards and regulations may be required with any new technique of space broadcasting that is not presently authorized. Accordingly, establishment of new systems before such agreements are negotiated should be on a strictly interim basis, permitting future modifications if such are required to conform to the new standards.

The primary technical problems associated with the deployment and operation of a satellite broadcast system in developing nations are in the areas of providing sufficiently trained manpower on a local basis, maintaining and operating the receivers, and the availability of spare parts and their storage in tropical climates.

It is also essential to evaluate the value of a satellite system for a developing nation as compared to its other requirements, in view of the fact that any country using such a system will depend on the United States or USSR for provision of launch vehicles.

The advantages and the potential of broadcast satellites may be tremendous, but because a satellite operates in the international domain of

Table 3

SUMMARY OF BASIC FEATURES OF SATELLITE TELEVISION DISTRIBUTION SYSTEMS

System*	Receiving Installation Configuration	Satellite ERP Required for High Quality Picture dBW (40dB S/N)	Feasibility of Achieving Required ERP	Possibility of Co-channel Interference	Regulatory Consideration Concerning Frequency of Operation	Satellite Spacing in Orbit to Prevent Interference	Cost of Receiving Installation	Cost of Satelli
AM-VSB/UHF/6 MHz (800 MHz)	TV set	91-97 dBW	Not feasible in foreseeable furture	Very high	Frequency band not presently authorized for space-to-ground use; utilized by terrestrial services	Very large	Very low	Very hi
AM-VSB/UHF/6 MHz (800 MHz)	Antenna, preamp and TV set	Depends on G/T of user's receiving system (see Figures 2 and 3)	Feasible by 1973 if R&D to obtain space-qualified design is accomplished	Very high		Large	Low	High
FM/UHD/40 MHz (800 MHz)	Antenna and preamp +FM demodulator +TV set		Feasible by 1972 if R&D for space-qualified design is accomplished	Not evaluated		Medium	Medium	Medium
FM/microwave/40 MHz (4 GHz)	Antenna and preamp +frequency changer +FM demodulator +TV set		Feasible now	Spectral power regulations limit ERP to 52 dBW, when 40MHz band is used. Antennas of 8-10 ft min would be required	Frequency band currently authorized for space and for terrestrial common carrier communications	Small	High	Low
FM/microwave/40 MHz (10 to 40 GHz)	As above	Becomes more sensitive to atmospheric conditions	Requires additional R&D to obtain ERP from space	Clear channel	Frequency band currently not allocated	Small	High	Unknow

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* Modulation technical/Frequency bank/RF bandwidth (nominal operating frequency)

outer space and its coverage cannot be limited to the boundaries of a country, many problems of international concern will arise. All of these problems must be fully evaluated and their potential future impact assessed before the United States undertakes to establish such a system for any developing nation.

Appendix A

INTERFERENCE CONSIDERATIONS

Limitations on the Total Number of Television Channels Around the Globe

Since each television channel occupies a predetermined RF bandwidth, depending on the method of modulation used, the first constraint on the total number of television channels is imposed by the availability of the spectrum.

AM-VSB (Amplitude-modulation vestigial sidebound) transmission, which is standard for terrestrial television distribution, requires 6 MHz per television channel. FM requires approximately 25 MHz of RF spectrum for transmission of one channel.

Thus, assuming that a total of 100 MHz is allocated to a particular system, approximately 16 AM-VSB channels could be provided, while only 4 would be available with FM. The choice between FM and AM is dictated by interference considerations.

The same frequency band can be reused to transmit another channel if no interference exists between the two systems operating on the same frequency. Assume that several satellites are available in stationary orbit and it is desired to transmit from all these satellites on the same frequency. Since frequency discrimination is not possible we must rely on the directivity of the ground antennas to pick up the transmissions from the wanted satellite and reject those from the other satellites. It is obvious that this establishes a relationship between the spacing of satellites in orbit and the type of ground receiving antennas that are utilized.

This relationship establishes the second constraint on the total number of television channels that can be provided by imposing a minimum requirement on the spacing of satellites in stationary orbit as a function of the directivity of the ground antennas. The directivity of the antenna is a function of its beamwidth which, in turn, is inversely proportional to the diameter and the operating frequency. Thus, the maximum permissible number of satellites in orbit decreases as the diameter of the ground antenna is reduced or the frequency lowered.

Since the primary consideration is the interference between the wanted and unwanted signals, only those modulation techniques that enhance the discrimination capability should be used. In this regard, it is observed that wideband modulation techniques, such as FM, are substantially superior to narrow band techniques, such as AM. In the resulting situation, FM will permit closer satellite spacing but will utilize more bandwidth per channel, while AM-VSB will require very large satellite spacing while utilizing relatively little bandwidth. Since the total number of television channels is the product of the number of satellites and the bandwidth available, the two requirements are incompatible and a compromise must be sought.

The implication is that the well-established concepts of frequency spectrum allocation must be supplemented by specifications on receiving antena directivity. Since the directivity is inversely proportional to antenna diameter (D) and to the operating frequency (F), the minimum spacing of satellites in orbit $\Delta\theta$ varies inversely with DF ($\Delta\theta = \frac{k}{DF}$).

The tendency to conserve frequency spectrum by utilizing narrowband modulation techniques has the effect of reducing immunity to interference. The directivity of antennas may become insufficient to permit closer angular spacing of satellites in orbit. Thus, by reducing the required bandwidth, the number of satellites that can be placed in any given section of stationary orbit is decreased. H. Rosen of Hughes Corporation gives the following example.*

For operation of UHF (800 MHz) with ground antennas of 10-ft diameter, the satellite orbit spacing to prevent harmful co-channel interference is 45°, assuming frequency modulation. Thus, only four satellite locations can serve the same region of earth without interference. If 100 MHz of UHF spectrum is allocated, only approximately four FM channels per satellite could be accommodated, and, since four satellites could be used, a total of 16 television channels can be obtained. If amplitude-modulation is used instead of frequency modulation, only 6 MHz of RF spectrum is required per channel permitting up to 16 television channels in a 100-MHz band. However, because of increased susceptibility to interference and corresponding increase in orbital spacing of satellites required, only one orbit location could be used. Thus, we would have a capacity of 16 channels per satellite but only one satellite in orbit.

The implications of this situation are clear. Either all those desiring television channels in one geographical region utilize the same satellite, thereby obtaining a clear channel, or some form of coordination between competing systems will be necessary to avoid interference. For example, a UHF satellite system for India that is designed to serve the users directly and employing small earth station antennas could become subject to serious interference if another country would place its own satellite, also operating at UHF, too close to the Indian one. The second country could achieve proper operation of its system by using larger size ground antennas, but the Indian system would be interferred with. Should the second country be unwilling to interfere with the Indian system, it would have to place its satellite in orbital positions which would not interfere with the Indian system and accept possible restrictions on the capacity of its own system.

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* AIAA, Vol. 6, No. 4, April 1968.

Although the requirement for television channels which will occur in the immediate future is probably small enough to be satisfied without creating any interference problems, it is apparent that some sort of international standards will ultimately be required to prevent future difficulties. Thus, any systems established within the next few years must be capable of modification when and if appropriate international standards are developed.

The above discussion assumes that all satellites radiate the same amount of RF power. If this is not the case, additional interference will be created with stations designed to receive lower power transmissions. Thus, ERP coordination between the two systems is also necessary.

From the preceding discussion we can draw the following conclusions:

- The selection of operating frequency, the size of ground receiving antennas, and the modulation technique determine the minimum permissible spacing in orbit of satellites operating in the same frequency band and radiating the same amount of power. This fact, together with the limitation on available frequency spectrum, imposes a limit on the total number of television channels that can be provided for any given region with acceptable interference. When planning such systems, the long term requirements of adjacent countries for similar services must be considered and agreements on the system parameters must be obtained ahead of time. Introduction of some international standards is clearly necessary to prevent future chaos from developing.

- Operation of television broadcast systems at higher frequencies, using frequency modulation and utilizing larger size ground antennas, will provide more global television capacity in any given frequency range than would be possible with AM/UHF operation and small stations.

Thus, direct broadcast to users at UHF utilizing AM-VSB tends to reduce the total television capability that can be provided by satellite systems.

Appendix B

SATELLITE SYSTEM RELIABILITY CONSIDERATIONS

System Down Time

Individual components of any system will fail eventually, thus totally or partially disabling the system. In case of a satellite in orbit, its failure will put the system out of action until a replacement satellite can be orbited.

To restore the service, the following must be available

1. Replacement satellite
2. Booster
3. Launching pad

Time delays associated with the availability of these items have been estimated as follows:

1. Replacement Satellite

To manufacture a satellite - 12 to 18 months

To assemble and flight-qualify a satellite from available parts - three to nine months

To prepare available satellite for launching - one to three months

These time delays include the time necessary for final checkout, shipment, and mounting of the satellite on the booster.

2. Booster

The availability of the booster depends on where it is procured. In the United States the procuring agency would probably be NASA, and the following delays could be expected:

No booster available at time of request - 12 to 24 months

Spare booster available - one to three months (this includes time necessary for shipment to launching site).

3. Launching Pad Availability

This item depends on the number of available launching pads and the frequency of their use. It is normally assumed that a turn-around interval between launches is from four to six weeks. Thus, to replace a satellite which has failed in orbit, a minimum period of approximately six weeks is required, even when the space satellite, launching pad, and booster are available immediately.

Probability of Successful Launch

Due to possibilities of malfunction, one must consider the possibility that a launch may fail due to:

Booster failure to attain orbit

Failure to successfully deploy the satellite after attaining orbit

As an example, with launch success probability of 80 percent and deployment success probability of 95 percent, the statistical number of launch attempts required to attain 90 percent confidence limit of successfully orbiting a satellite is 1.7. This suggests that one should be prepared for the possibility that two launches may be needed to successfully orbit the satellite.

In such a case, if two satellites and boosters are originally available, a time delay of approximately 12 weeks may be expected. If they are not available, a considerable delay in restoring system operation can occur.

Maintenance Strategies

As can be seen from the above discussion, means to prevent system down time must be developed. Some possible strategies are:

Redundant (standby) satellites in orbit

Backup terrestrial network

Use of several smaller capacity satellites to reduce areas of outage

Other Possible Causes for System Down Time

In addition to failures, the system can be rendered inoperative by other means:

Predictable outages (eclipses, sun transit, and so forth), which are normally short term

Interference from other systems

Intentional jamming

Consideration of these items is outside the scope of this report. It should be remembered, however, that satellite systems are totally vulnerable to intentional jamming and can be completely disabled by a determined jammer. It may not, therefore, be advisable to use a satellite to handle any communication or educational functions that may be considered to be of vital importance to the country.

Summary

The relative importance of the system down time must be assessed as part of system design, and appropriate preventative policies must be developed. The cost of these preventative measures should be included in the total cost of the system.

Appendix C

TELEVISION STANDARDS AND PICTURE QUALITY REQUIREMENTS

This appendix includes a brief summary of the operating requirements of television systems that are pertinent to comparative systems studies.

Frequency Allocation for Television Service

Television operations throughout the world are contained mainly in the following frequency bands:

41-68 MHz
174-216 MHz
470-585 MHz

In the United States, the frequencies assigned by FCC (Federal Communications Commission) to commercial television broadcasting are:

Frequency	Channel	Identification
54-88 MHz	2-6	Lower VHF
174-216 MHz	7-13	Upper VHF
470-890 MHz	14-83	UHF

Frequency bands allocated for transmission between communication satellites and earth stations are distributed throughout the frequency range from 3.4 to 8.4 GHz. In the United States, the 4-6 GHz bands are shared between the common carrier satellite and terrestrial services, while 7-8 GHz bands are used by government communication satellites. Table C-1 summarizes the broadcast frequency allocations in the three geographic regions defined by CCIR and within the United States. Table C-2 summarizes common carrier allocations for terrestrial and space services.

Table C-1

TELEVISION BROADCAST FREQUENCY ALLOCATIONS

Region 1	Region 2	Region 3	United States	FCC
41-68 Broadcasting		44-50 Fixed, mobile broadcasting		
	54-73 Fixed, mobile broadcasting	54-68 Fixed, mobile broadcasting	54-72 Nongovernment	54-72 Broadcasting TV
	74.4-88 Fixed, mobile Broadcasting		76-88 Nongovernment	76-88 Broadcasting TV
87.5-100 Broadcasting	88-100 Broadcasting	87-100 Fixed, mobile broadcasting	88-108 Nongovernment	88-108 Broadcasting FM
		170-174 Fixed, mobile broadcasting		
174-216 Broadcasting	174-216 Fixed, mobile broadcasting	174-216 Fixed, mobile broadcasting	174-216 Nongovernment	174-216 Broadcasting TV
216-223 Aeronautical, radionavigation, broadcasting				
470-582 Broadcasting	470-890 Broadcasting	470-585 Broadcasting	470-890 Nongovernment	470-890 Broadcasting TV
582-606 Broadcasting, radionavigation				
606-790 Broadcasting		610-890 Fixed, mobile broadcasting		
790-890 Fixed broadcasting				
890-942 Fixed broadcasting		890-942 Fixed, mobile broadcasting		
942-960 Fixed broadcasting		942-960 Fixed, mobile broadcasting		

Table C-2

ALLOCATIONS TO COMMUNICATIONS SERVICES
(1-12 GHz/s)

Frequency Band (MHz/s)	Allocation	
	United States	International
1710-1850	Fixed, mobile	Unspecified government
3500-3700	Fixed, mobile Radio location; Comsat	Unspecified government
3700-4200	Same as above	Common carrier, fixed space
4400-4700	Same as above	Government unspecified
5925-6425	Same as above	Common carrier fixed
7250-7300	Comsat	Comsat (space)
7300-7750	Fixed, mobile Comsat	Comsat, Metsat (space)
7900-7975	Same as above	Comsat (earth)
7975-8025	Comsat	Comsat (earth)
8025-8400	Fixed, mobile, Comsat	Fixed, mobile, Comsat (earth)
11,700-12,700	Fixed, mobile, broadcasting	Common carrier, TVSTV, and pick-up

Television Standards

The discussion in this report is based on television standards applicable to the U.S. industry (525 lines, channel width of 6 MHz, video bandwidth of 4 MHz. Three other systems are used throughout the world, and their characteristics are summarized in Table C-3. Because of technical differences, the minimum requirements for SNR (signal-to-noise ratio) will vary. Because of the subjective nature of quality determination, however, it is believed that data developed for U.S. systems will be representative of all systems, provided proper adjustment for differing bandwidths are made.

Table C-3

WORLD TELEVISION STANDARDS

Characteristic	A	B	C	D
Number lines per picture	405	525	625	819
Video bandwidth (MHz/s)	3	4	5	10.4
Channel width (MHz/s)	5	6	7	14
Interlace	2/1	2/1	2/1	2/1
Line frequency (Hz/s)	10,125	15,750	15,625	20,475
Field frequency (Hz/s)	50	60	50	50
Picture frequency	25	30	25	25
Sound modulation	AM	FM	FM	AM

Picture Quality Requirements

For conventional television broadcasting at UHF in the United States, the FCC has specified several grades of service and corresponding signal strength requirements. Table C-4 shows these requirements and the satellite ERP that must be produced to meet these requirements.

The required signal strengths shown in Table C-4 are those specified by the FCC to be used for calculating the different grades of service for conventional television using ground-based transmitters. A close correlation between these values and SNR has been established from detailed studies of empirical data conducted by TASO and collected in the New York UHF-TV project. The pertinent results of these studies are tabulated in Table C-5.

Table C-4

FCC REQUIREMENTS FOR TELEVISION GRADES OF SERVICE

Grade of Service	Quality Description	Signal Strength Median Value of (Chs 14-83 [UHF] µ volts/meter)	Power Density (watts/m^2)	Approximate Corresponding Satellite ERP	
				Watts	dBW
	Not explicitly defined.	10,000 µ v/m	2.65x10^7	4.8x10^9	97
A	Quality acceptable to a median observer that is available 90% of the time at the best 70% of receiver locations at the outer limits of the service area.	5010	6.66x10^8	11.7x10^8	91
B	Quality acceptable to a median observer that is available 90% of the time at best 50% of receiver locations at the outer service area.	1580	6.61x10^9	1.2x10^8	81

Table C-5

PICTURE QUALITY MEASUREMENTS

Signal Grade	Description	Median Observer SNR in dB
1. Excellent	Picture is of extremely high quality.	42
2. Fine	Picture is of high quality. Interference is perceptible.	33
3. Passable	Picture is of acceptable quality. Interference is not objectionable.	27
4. Marginal	Picture is poor in quality. Interference is somewhat objectionable.	23.5
5. Inferior	Picture is very poor. Interference is definitely objectionable.	19
6. Unusable	Picture is so poor that it could not be watched.	10

The above data has been developed for ground-based television broadcasting and is not entirely realistic for space transmission. A better approach is to relate the output SNR to the SNR at the input to the receiver, taking into account the antenna gain, receiver noise figure, modulation improvements, frequency of operation, and so forth.

It is normally accepted for purposes of comparative analysis that an SNR of 40 dB at the input to the receiver will produce a high quality picture (assuming U.S. television standards). Using a figure of approximately 14 dB for the combined effect of noise weighting the preemphasis characteristic, this results in a SNR_{wt} (signal to weighted noise ratio) of approximately 54 dB, which is applicable to FM transmissions. When the signals are relayed from the satellite receiving station to the user, the SNR_{wt} at the output of the satellite earth station is normally taken as 56 dB.

Appendix D

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Working Paper No. 5

POLITICAL OBSTACLES TO ADOPTION OF EDUCATIONAL TELEVISION

by Guy Benveniste

A Conceptual Framework for the Analysis

There exists in all developing countries a public administration, a political machinery, a bureaucracy, and an educational system, with its status ladder, its incentives for attracting teachers, and its controls to regulate performance of educators and students. There also exist other organizations that will have a stake in ETV: broadcasters, manufacturers of equipment, parent and student organizations, political parties, and so on.

The introduction of ETV, whether satellite- or terrestrially-based, can be regarded as a significant alteration of the environment in which the foregoing organizations operate, and this alteration affects the ways individuals within these organizations pursue their individual and collective objectives and the ways organizations as a whole survive and prosper.

Three types of organizations can be distinguished:

1. Existing implementing organizations: for example, the ministries of education that will implement the utilization of educational television programs in classrooms; the ministry of finance and the planning agencies that will have to approve recurrent and capital expenditures; and the broadcasting organizations that may elaborate programs.

2. Nonexisting implementing organizations: new organizations that may have to be created.

3. Controlling organizations: nonimplementing organizations that in one way or another can control the performance of the implementing organizations; for example, political parties in developing countries would not implement ETV but could, in certain situations, oppose its utilization.

With the purpose of clarifying issues, the following analysis has been prepared without any attempt to introduce first-hand field data. The purpose of this analysis is to suggest generalizations of situations that may be found in most developing countries. This analysis must remain very preliminary and does not provide any definitive answer as to what might be the political feasibility of ETV in one or more countries. However, it may provide some indication of the type of issues, conflicts, or problems that might be encountered, should a government decide to implement an ETV system.

The Ministries of Education

In most developing countries, the administration of education is far more centralized than in the United States. Usually there exists a national ministry of education that has extensive responsibilities for primary or secondary education and sometimes for higher education.

In certain federal countries, in India, for example, the state ministries of education seem to be more influential than the federal government in the making of many educational decisions affecting the states.

In other federal countries, such as Mexico, the federal ministry of education is by far the most powerful institution controlling education.

These ministries of education usually have similar characteristics. First, they tend to be less innovative than other ministries. This may be because of their low prestige in the affairs of state or simply a reflection of their large numbers of vocal employees who resist change. But in many countries where administrative practices have been modernized in, say, finance, public health, and agriculture, the ministry of education is often operating as it did 20 or 30 years ago.

This indicates that in most developing countries a significant portion of educational decision-making is in the hands of a large bureaucratic system that has been able, over time, to consolidate and routinize its practices to minimize tension and friction among the various components of the educational administration.

Therefore, ministries of education are often composed of relatively autonomous departments--for example, primary, secondary, technical, vocational, adult, out-of-school, and visual aids departments. These departments tend to maintain a fierce autonomy, thus providing a modicum of security to their staff. They tend to busy themselves with their own concerns and limit contacts with other departments to a strict minimum. Careers are usually started and terminated within departments. To avoid the need for coordination, every effort is made to routinize practices and provide rigid rules that allow for limited interpretation or innovation.

The ministers of education are usually political appointees. But a new minister of education usually inherits a bureaucracy that he does not statistics ensure the independence and autonomy of departments in their resistance to succeeding generations of ministers (and their immediate staff) who come and go according to the vicissitudes of the political process of the nation.

It might, therefore, be an oversimplification to assume that the existence of centralized ministries of education ensures or facilitates the introduction of national innovations in education. A well-disciplined set of quasi-independent empires can, each in its own way, resist any change that might threaten the established routines that provide security and continuity to each department.

The Corps of Inspectors

In most ministries of education there will be one, and usually more than one, corps of inspectors. If the departments have achieved considerable automony, they usually will inspect their own staff. The inspectorate in education provides avenues for career development. Teachers can aspire some day to become inspectors. Once they reach that position, they are influential in controlling the salary advances and the job location of their colleagues. Thus, the inspectorate may be an influential voice in a ministry of education. But where the inspectorate is controlled by the departments, it tends to reinforce their autonomy and ensure compliance of the staff of each department to its leadership. Thus, the system of evaluation and promotion that exists in these large bureaucracies is not usually controlled by the minister of education, but by the heads of departments--members of the permanent civil service--who have made their career within the ministries.

Therefore, the various departments in the ministry have an important voice in policy-making, and the permanent civil service is often more influential than the minister. This, of course, is particularly relevant to the introduction of an ~~new~~ educational innovation that may affect many departments.

Innovations Within Departments

It would be erroneous to assume that these routinized bureaucratic organizations fail to innovate. Faced with a changing external environment where, as a result of economic, social, and political changes taking place in the world, new pressures are brought to bear on old structures, the various autonomous departments of ministries of education do innovate; but innovations are usually limited in scope and rarely go beyond the confines of any one department.

Ministers who are appointed for a limited period of time, or who know from experience that their appointment cannot last for too long, usually seek to achieve some change during their brief tenure. They will often ally themselves with some innovators who are seeking changes. They may be able to organize coalitions of innovators across departments, but more generally these innovations will seek to reinforce and consolidate the position and safety of the existing departmental structures.

At times, of course, ministers may attempt to break the rigidity and structural compartmentalization by creating new organizations to bypass existing ones. And new organizations may sometimes flourish and consolidate their hold within a ministry. However, if the new organization seriously threatens the security of the existing departments, it is usually eliminated.

It is always useful to note the relative lack of importance of departments of visual aids and, more particularly, of ETV in most ministries of education. When ETV exists, it will usually have a very limited program. Budgets must be applied to activities that do not displace or threaten any significant numbers of the staff of other departments. The object is to provide teaching aids without replacing teachers.

Pilot Projects

Attempts to experiment with ETV are often allowed at the pilot project level. Pilot projects, of course, provide a palliative to many conflicting pressures. Innovators are given a chance to demonstrate what they can do, but the effects on existing administrative structures are controlled. Thus, most attempts to use ETV in centralized educational bureaucracies (with some exceptions, such as in Japan) are actually very limited in scope.

Nonthreatening Innovations

Where important programs have been initiated, for example, Telescuola in Italy, the innovators have consciously attempted not to threaten the existing structures. Telescuola was specifically organized to provide programs for rural areas where secondary education could not as yet be provided. It did not threaten the expansion of the conventional secondary schools. It was always understood that Telescuola was a temporary solution that was to give way to conventional secondary education when human and financial resources become disposible.

Similarly, the French ETV programs were originally conceived as a temporary substitute for a shortage of trained secondary teachers in the sciences, particularly in mathematics. In time, of course, the ETV of the French National Institute of Pedagogy was able to acquire local support among certain administrative structures and has resisted being abolished. But its impact on French education has been effectively constrained by the fact that teachers can always turn the set off. While no precise measurement has been made of the extent of this type of resistance, some observers believe that it may be widespread.

The Teachers' Unions

In many countries, teachers' unions have been organized to defend the interests of their membership. The government has tended to limit their power, particularly when a large percentage of their membership are government employees. For example, the teachers' union in Mexico, like most of the other unions of Mexican government employees, has been kept under strict control by the Mexican government. From time to time, it has not been uncommon for governments to use military force to bring a government union leadership back into the ranks when this leadership has appeared to bypass the limits of its own authority.

But while constrained, teachers' unions nevertheless can have a powerful voice in the political life of the nation when the issues they raise reach national significance. That is, when teachers can articulate issues that concern not only themselves, but other sectors of the political life of the country as well. When this happens, teachers can be a very important political force, simply because they can organize a large and very vocal pressure group.

The most important issues for teachers' unions are those related to salary increases, and any threat to a possible salary increase will generally be fought. It is therefore reasonable to expect that teachers' unions would strongly oppose any government policy that might allocate more funds to education without a corresponding increase in salaries. In short, it should be assumed that any government announcing an intent to adopt ETV, and to devote considerable funds to this purpose, would face considerable opposition from the teachers' union. The union leadership would insist that teacher salary demands be met.

As long as the teachers' union is opposed to ETV on the grounds that it affects the monetary well-being of its membership, such a project may receive only token support from other political organizations, although it would be reasonable that other unions--either government or nongovernment--might provide considerable support. However, it can be assumed that governments that have been able to effectively control past salary claims of the union leadership would be able to do so again. Teachers' unions are usually led by politically sophisticated leaders who would be aware of this problem. It is therefore logical to expect that the unions would attempt to present the issue in such a way that it would reach the concerns of a large percentage of the politically active population. For example, it would not be unreasonable to assume that if an ETV system can, in any way, be perceived to be a foreign encroachment on national sovereignty over education, this could provide a main theme for a teachers' union formulation of the issue.

In most, if not all, developing countries, formal education has become a responsibility of the state. In many countries, this responsibility can be delegated to private (including foreign) organizations. But this delegation is usually subject to considerable control from the state. If an ETV system can, in any way, be perceived to be some kind of delegation of authority on education to another foreign power, this delegation of authority could become a highly charged national political issue, unless suitable controls remained in the hands of the national government.

This would suggest that any ETV system needs to be conceived in such a way that it cannot be viewed as a delegation of the authority that a state has on its own education. This would imply that control of the content of the message being transmitted, and control of the availability of the transmitting hardware, cannot be reasonably expected to remain exclusively in the hands of any single foreign power.

The teachers' unions, for various reasons, can be expected to oppose any large scale attempt to use ETV. First, it may seem to the unions to be a deliberate effort of the government to divert resources from a possible salary increase. Second, in the long run, ETV implies less reliance on manpower in education. Threatened or real reductions in the total future numbers of teachers is not going to please a union leadership that still relies on the sheer weight of numbers in exerting political pressure on the government.

However, while the unions can be expected to take a negative stance, it may be that they would not be able to stop such a development unless the leadership of the unions could formulate the issue in such a way that it creates nationwide concern going far beyond the immediate interests of the membership or leadership of the union. Therefore, it is necessary to conceive of an ETV system that does not lend itself to such a formulation of the issue.

Competition Among Ministries

Until now, the discussion has centered on some of the problems that may be encountered within the ministries of education. The relationships among the ministry of education and other ministries, particularly with the Ministry of Telecommunication, should also be considered.

In many countries several ministries have been able to acquire and maintain certain educational programs that they consider essential to their own activities. Thus, it is quite common to find that military schools are administered directly by the ministry of defense; agricultural schools and extension services are often under the ministries of agriculture; and special training schemes are provided by most ministries for their staff.

This division of labor usually means a partial encroachment on the ministry of education, and it is not too uncommon to find that the relations between the ministry of education and the ministries of agriculture, community development, and others are tense, and have been for many years.

The experience with ETV has not always been a good one since, as a rule, ETV has received far more support from ministries of telecommunication than from ministries of education. Very often, it is the ministry of telecommunication that has been pushing the idea of television in general and of ETV in particular. For the ministries of telecommunication, state intervention in television is made more reasonable because of its possible educational application. External support for pilot ETV schemes has often come from telecommunication organizations in other countries, and the notion of ETV has often been used to argue for state versus private development of television.

Ministries of education have often been reluctant to embark on pilot ETV schemes, but they have often done so to meet the demand of governments that are anxious to ensure that television remain more in public than in private control.

While pilot projects may have been acceptable, the implications of a satellite-based ETV system for the sharing of educational responsibility between ministries of education and ministries of telecommunication is a problem that will usually concern both types of ministries. For the ministries of education, the problem is to ensure that the participation of the ministries of telecommunication is strictly limited to technical considerations ("hardware"). The responsibility for the selection, elaboration, and scheduling of programs ("software") is an educational activity that should be in the hands of the educator.

However, it is not always easy to make such a straightforward separation between hardware and software. Quite often, the only groups with operating experience in television are in telecommunication and not in education. Even if television teachers are to come from education, production of programs requires many diversified talents, ranging from production directors, cameramen, and script writers to recording technicians. These types of talent are usually already operating in telecommunications, and making arrangements for a clear-cut division of labor between ministries will never be easy.

If too much emphasis is given to making production a responsibility of education, it is probable that telecommunications will see a threat to its own interests. In the long run, the ministry of education could thereby take on some of the functions of telecommunications. On the other hand, if too much emphasis is given to making production a responsibility of telecommunications, education will perceive a direct threat to its own interests. It may well be that the solution to this problem is the invention of a special implementing organization, jointly controlled by both ministries. But even so, problems may arise with the existing departments within the ministry of education. As mentioned earlier, the departments within the ministry are jealous of their autonomy. They have been able to settle problems of overlap within the ministry by the play of political forces, and over time they may have accommodated to a modus vivendi.

An external agency controlled by two ministries removes the arena of conflict from within the ministry of education. This, in fact, means that problems between the departments of the ministry of education and the new agency must be arbitrated by the minister of education who, together with the minister of telecommunications, would administer the new agency. This would tend to remove social power from the hands of the long term career civil service personnel who run the departments and place it in the hands of shorter term politicians who are appointed to head the ministry. It can therefore be expected that such a course of action would be fought by departments within the ministry of education.

The State Universities

In most countries, the government-financed universities are administratively independent from the ministry of education, even if they receive financial support from the ministry's budget.

More importantly, the career service in education is usually sharply divided between primary school teachers trained in normal schools, secondary school teachers having a subject matter specialty and somewhat more preparation, teachers in primary and secondary education, and professors in higher education, so that transfer from one level to another is rarely possible. (There are some exceptions, of course. For example, in France, the career service distinguishes between primary, on one hand, and secondary and higher on the other. It is therefore relatively easy to start as a secondary school teacher and become a university professor).

However, the problem of career limitation does not stop there. Universities and institutions of higher education in developing countries tend to fit into some kind of highly structured stratification system. If there are institutions in the capital, these will tend to assume a predominant role. A few institutions in the provinces may also become well known, particularly if encouraged by external aid agencies. Behind the few elite centers of excellence, there are usually found many other institutions groping for a place in the social ladder of education. But between these different institutions there tends to be very little mobility of personnel.

Transfers from the provinces to the center tend to be rare. Within circles of equal prestige, there is a tendency to move and advance, but it is rare that professors who start in the provinces find it easy to gain access to the centers of excellence. This lack of social mobility within the teaching staff of institutions of higher education in many developing countries can have serious implications for a widespread ETV system.

Since the best teachers can aspire to become television teachers, it would be normal to expect that ETV would tend to reinforce the status of the elite schools. This, in itself, is not necessarily bad, but from the point of view of teachers and professors initiating their career, it tends to mean that there is a further and sharper differentiation between career opportunities in the center and the opportunities in the provinces.

The administration of the weaker schools would therefore tend to see the introduction of a nationwide ETV system as a negative influence. To be sure, the argument for ETV is that the best professors from the best universities can influence education in the second- or third-rate institutions. However, if this means that this will tend to further differentiate the few good institutions from those that are mediocre and the inferior, and that these find it increasingly hard to acquire good teachers, then, of course, there may be negative consequences. It is the fear of these negative consequences that may lead to the administration of the mediocre institutions of higher education to oppose ETV, and it is the perceived further reduction of status of the faculties of these institutions, combined with the absence of any hope of profit from the changes and opportunities that television might offer for career advancement, that would underline the opposition of these faculties.

The Private Educational Sector

The private educational sector in developing countries is rarely a homogeneous group of institutions. Its importance also varies from country to country, depending on historical factors and the policies of government.

The private sector includes the following types of institutions: church-controlled schools (including foreign missions); schools partially supported by private sector interests (industry, banking); schools partially supported by fees from students (i.e., secondary and technical education); and schools partially supported by foreign aid.

In general, the private sector of education in developing countries is poorly organized. When the schools receive financial support from other organizations (church, orders, missions, banks, industry, professional or civic organizations, etc.), the educational objectives of the sponsors may differ and hamper possible cooperation. The relationship to government is never completely compatible, and when subsidies are concerned, the government has usually tended to seek different arrangements with different groups to avoid any possible confrontation with a unified private education sector.

It is not unusual to find considerable interest in ETV within that part of the private educational sector that is concerned with education for nonmonetary considerations. Groups that sponsor schools for ideological or religious reasons tend to be open to new approaches that may help them carry their purpose forward. For example, in certain Latin American countries, pilot ETV schemes have received considerable support from church, private industry, and banks, because these schemes are often perceived as a means of reducing the possible undesirable political influence of certain ideologies within the teaching professions. But cooperation and coordination of private endeavors are not always easy to organize, and the scope of the activities ~~are~~ is limited when it becomes too apparent that the private sector is attempting to influence what happens in government institutions.

On the other hand, the private sector in education is usually very suspicious of government use and control of ETV, since this is usually perceived as an attempt to further reduce the degrees of freedom that private groups may have in pursuing objectives that differ somewhat from those of government.

It is not unusual to find that where they have been allowed to operate, the private television entrepreneurs, who already have acquired a certain production sophistication and who usually have access to capital markets, are interested in experimenting with ETV for various reasons: first, because it may be a paying business proposition in its own right; but more importantly, because it may provide a kind of civic legitimacy for commercial television. This latter factor may help explain many private undertakings in Latin America.

To summarize, as a rule, the private educational sector does not provide a coherent or integrated position regarding ETV. Private interests and objectives tend to be varied and fragmented. If a private group is interested in ETV, it tends to prefer schemes that it can influence and to be suspicious of schemes that imply government intervention.

It can therefore be expected that in many instances where the relationship between government and the private sector in education is not absolutely harmonious to start with, the introduction of ETV might not be favored by a private sector, if the private sector tends to believe that such a large scale scheme will necessarily reinforce the government's hand in education.

But in those countries where the private sector has, in one way or another, some controlling influence on government educational policy, ETV can be seen as a means to exert greater private sector influence on government schools. For example, it would be reasonable to expect that in those Latin American countries where the Catholic church still has considerable influence on government policies, there may be considerable interest and support within the private sector for a government scheme to use ETV. But in those Latin American countries where government education has managed to liberate itself of the influence of the church, such a scheme is likely to be opposed by the private sector.

Student Organizations

Student organizations have in recent years acquired a worldwide prominence. In many countries, particularly in Latin America, university students have been politically active for many years and can be very effective in dealing with certain issues. They have acquired considerable power and, in fact, have a voice in university administration in quite a few Latin American universities. There should be little doubt that as enrollments in higher education expand, with all the implications that high rates of growth imply for any organization (such as dislocation in administrative procedures and, more generally, simple errors of planning and implementation), there will be increasing sources of friction between students, faculties, and administration.

A more fundamental cause of the problem lies in the fact that, as higher education is made more democratic and as a larger percentage of the school age population graduate from colleges and universities, the privileges once associated with higher education tend to be downgraded. Whereas in the past the investment of several years in higher education was perceived to be a guarantee that would lead to a distinguished career, it now appears that in many developing countries the economy cannot absorb, at least not immediately, the output of many institutions. This is particularly true in certain social science disciplines such as sociology, political science, or even economics, but is sometimes also true of disciplines in the physical hard sciences. Thus, the student faces an uncertain future, and this uncertainty is often central to his participation in student movements.

One characteristic of today's student movements is that they seem to tend to lack focus and be utopian in character. The usual pattern is one of many different organizations, each identified with a different ideology, going from the extreme left to the extreme right. This multitude of independent student organizations often disagrees on many issues but combines to act on those problems on which they all can agree. When they combine force, they can be very effective, as illustrated by the fact that many a rector in Latin America rarely expects to remain in office more than a few years.

One natural objective of student organizations is to acquire a greater voice for students in educational decision-making, and thus to reduce student dependency on teachers and other evaluators. To be sure, in many countries students already have a limited voice in educational policy-making. But there is every reason to believe that as the numbers enrolling in institutions of higher education get larger and as many older professionals increasingly return to universities for study, student organizations will tend to be a far more demanding and effective power in university life.

It can be assumed that ETV might be seen as a threat by the student political leadership. It can be argued that removal of day-to-day confrontations with faculty might actually reduce the political effectiveness of the student leadership. In fact, it can be argued that an improvement and upgrading of the quality of education, while desirable for students, might be less than desirable for the student political leaders, who often base their growing source of power on the fact the education is inferior and that students have legitimate complaints to make.

Therefore, caution is suggested in introducing the idea of ETV to the leadership of student organizations. It may be that some students, as contrasted to student leaders, may support an approach that offers expectations of educational improvements. But it is probable that many student organizations will attempt to make certain the scheme fails.

Concluding Remarks

This brief and illustrative discussion serves to point out that the introduction of ETV is bound to produce a major change in the environment of a large number of important and powerful organizations that are already active in education in any developing country.

This discussion has speculated about the possible reactions of some of the more important and self-evident groups. However, the list of possible interested parties has not been exhausted. In some countries, parent organizations or alumni organizations may be significant. In others, educational planners may be influential in decision-making, and their own political bias might make them a possible opponent of a scheme that may appear to their cautious eyes to be too risky. This may seem odd at first, since it might be expected that educational planners would favor an innovation that seems, on rational grounds, to be logically necessary.

However, it can be shown that educational planners tend to be cautious and to avoid political risks because of the precarious position they occupy in ministries of education and the relative innovation that their own position implies in the administrative structure of ministries of education.

Other relevant groups may include foreign professional experts who are advising the ministry of education, some of which, for professional or other political reasons, may be opposed to ETV. In some countries, there may be various pedagogical research institutes and normal schools where positions on ETV have been taken, or might be taken, and whose influence needs to be considered. The possible interests of various school suppliers who might become obsolescent, should television be introduced, should also be considered.

This discussion has stressed the characteristics of the possible opposition to ETV that would make it improbable that such a system might be implemented, notwithstanding the fact that such an approach might be feasible from other points of view.

The characteristics of the possible opposition that has been described leads to the following conclusions:

- An ETV system might have to be established in a series of sequential steps, so that each time the scope of ETV service is enlarged, the number of educational organizations that are affected is limited. Thus, coalitions between opponents might be avoided, and adjustments to the changes brought about by the introduction of ETV might take place over long periods of time.

- The initial focus of ETV should be programs that avoid threats to existing organizations. This, of course, may be a limiting constraint for a time, but it does not seem reasonable to expect existing educational organizations to accept passively a reduction in their influence.

- It is highly improbable that any ETV system could be established if it appears that in so doing a nation is reducing its national sovereignty over its own education.

- Any plan for the introduction of ETV in a developing country should take into account the nature of the opposition that it might engender. It should also consider what system configuration might receive effective support, at least in some quarters. It is desirable that this type of research be undertaken by well-qualified social scientists in the countries considering establishment of such an innovation.

- This brief discussion may have highlighted more problems than it has provided solutions. But it would not be reasonable to expect that a major educational innovation could be introduced in any soverign country without taking into account the type of political considerations mentioned here. These political considerations create further constraints on the ways in which ETV might be initiated. But these constraints, even if they have a cost, are not necessarily limiting. What is limiting is to disregard political reality and assume that once technical or economic feasibility has been demonstrated, any government will simply adopt this innovation.

Working Paper No. 6

ECONOMIC ANALYSIS OF THE ALTERNATIVE DISTRIBUTION SYSTEMS FOR EDUCATIONAL TELEVISION

by Andrew J. Lipinski

Introduction

The objective of this economic analysis is to provide a basis for comparing the various systems for distributing ETV.

The primary input to the analysis is the "demand" for ETV expressed in terms of weekly hours of new program material, number of reception points, and number of production centers. The outputs are the initial costs, the annual operating costs, and the year in which these costs are incurred. The costs are subdivided into four categories: external and internal material costs, and external and internal manpower costs.

Cost Elements

The time period used in constructing the models was 10 years--1970 through 1979. Some of the elements considered in the establishment and operation of any instructional system may be written off fully within a 10-year or even a shorter period. For example, a satellite's useful in-orbit life may be five years, and because of the less-than-perfect launch reliability, its expected life may be three years rather than five. Thus, one-to-three satellites (and boosters) will be fully depreciated within the 10-year period, depending on the starting date.

In contrast to satellite costs, certain other costs incurred within the 10-year period are amortized over a much longer time span.

Buildings, for instance, may be depreciated over 30 years (and may actually last much longer); and it is customary to depreciate microwave links over a 15-year period, even though their actual service life (depending on the replacement policy of the telecommunications administration) may be twice as long. Satellite earth stations are, at present, assumed to have a useful life of 10 years; they may serve considerably longer.

Because of these and other considerations, depreciation and amortization costs were excluded from the analysis.

The cost of capital, that is, interest charges, presents a similar problem. Few of the country administrations operating in the areas covered by this study have sufficient internal capital resources; most would have to raise funds for educational technology by borrowing abroad. The interest rates and the terms of the loan will vary depending on the lender, the economic situation of the borrowing country, and the political conditions at the time of borrowing. Take, as an example, a case in which a long period of grace is offered by the lender and neither capital nor interest would need to be paid for the first 10 years. The capital costs falling within the analysis period would be zero, and as a result, the comparison of costs would be distorted in favor of projects financed in this way.

Even though the actual choice among alternative instructional systems might, in fact, be dependent on which system could be offered on the most attractive terms, the comparisons of loan conditions would entail forecasting the policies of major lenders, which is considered to be outside the scope of this study.

For these reasons, the calculations presented here do not show depreciation costs and interests costs but, instead, show only the initial costs. Since initial costs are clearly identified, it is not difficult to distribute depreciation over any desired period, or to add interest at whatever financial terms are deemed appropriate.

Revenues

Some of the components of an instructional system may be used to generate revenues that would help to defray a part of the expenses. Several possibilities suggest themselves:

- The microwave links and/or the television system could carry noninstructional products.
- Trucks carrying video tape could carry other products.
- Studios producing instructional material could equally well supply entertainment material, and the television sets could be used to receive it.

It is likely that some instances of a shared use of facilities will occur. However, to include in the comparisons presented here the revenues thus generated would entail a host of additional, very tentative assumptions regarding rates, administrations and INTELSAT policy, availability of facilities, and international agreements. For these reasons, the analysis does not consider the revenues or joint costing for noneducational uses.

Elements of the Instructional System

Following the current practice, the instructional system has been divided into three elements: production, distribution, and reception. The main purpose of the production element is to prepare the program material and the supporting literature and manage the entire programming system. This element includes the main and the satellite production centers.

The purpose of the distribution element is to convey the instructional material to the reception sites. It includes the transmission system (terrestrial transportation, microwave, or satellite); the broadcast stations; and, if necessary, any intermediate storage points of instructional material. The distribution element also includes the components of educational feedback: field research teams, their conveyances, and other costs associated with program evaluation.

The reception element comprises the elements that directly serve students: television sets and other educational aids, such as video recorders. If the method of transmission is direct broadcast to a school or a school set, then the necessary hardware (antenna, preamplifier, and so forth) are included. Teacher training is also considered as related to reception.

The Evolution of the Instructional System

In the past, two approaches have been used in evaluating the efficacy of alternative instructional systems. In the first approach, the entire system is established in what might be termed the "educational wasteland." Either satellites, microwave network, or airplanes convey the instructional material to the end user. Moreover, an entire system often is assumed to be established at one point in time. Costs of different systems are then compared. The artificiality of this method is met with an admission that in actuality a mix of systems would offer some advantages. This approach has the merit of simplicity and, for some poorly developed countries, may even be reasonably realistic, except in terms of the important consideration of funding.

The second approach is more realistic, but also more complicated. The instructional system is built, step by step, starting with what exists, proceeding with what has already been planned, adding new elements, and finally achieving a goal of a certain desirable coverage of the territory or percentage of the population by a certain date. This is the approach used in this study.

This approach does not lend itself to simple comparisons; contingencies abound, and comparisons are valid only in the narrower range of time and circumstances. Nevertheless, this approach is considered to be more valuable: it is more realistic, and its very complexity illuminates the interface problems that are omitted in the simplified approach.

Means by Which Program Material Can Be Distributed

Shipment of Video Tape by Trucks

If there are no requirements for a real-time distribution of instructional program, the master program can be reproduced on as many tapes as desired, and the copies can be distributed to the broadcast stations.

The disadvantage of video tape as an instructional tool is that it is impractical without a substantial back-up of inventoried material. Opinions differ regarding the amount to be stored. The required size of the inventory is somewhat related to the means by which program material is transmitted, since allowances must be made for a missed shipment. If, for instance, a batch of tape is shipped by road every two weeks, then it is reasonable to store at least a two weeks' reserve of program material. If three-months storage is required for other reasons, then the shorter delay does not matter. To safely cover all contingencies, a four-month supply has been allowed in the analysis.

Transmission of Video Material by Microwave Links

Broadcast stations are, in most cases, placed near major population centers that eventually are connected by multichannel telephone transmission systems. In principle, both cables and microwave links can be used for transmission of video, but microwave links are more suited for it. A heavy density (600 telephone channels or more) microwave link that has been built to connect major cities will have a capability of carrying from one to 10 two-way video channels. When the installed television capacity is inadequate, additional equipment needed to extend it is only a small fraction of the original cost of the link.

But if there is no microwave connection, new heavy-density equipment is quite expensive--roughly $250,000 per "hop" of 25 miles.* It is very unlikely that such a link will be built solely for ITV. Rather, it will be built by the telephone administration as a part of the overall telecommunications development plan. Unfortunately, there are no means of predicting the charges, if any, made for the services of the telephone administration. Neither, as will be explained later, is it easy to predict the arrangements that might be made by the national administration with INTELSAT for the transmission of television programs to schools using the INTELSAT satellite. To avoid these difficulties, an independent satellite system for instructional purposes is assumed here. And to be fair in the comparison of satellite versus microwave transmission, the instructional system also is assumed to bear the entire cost of a new microwave facility or of an addition to the existing facility.

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* An appropriate cost of a two-way television link in a "1 + 1" (one standby for one operating channel) configuration, including site preparation, access road, power supplies, and so forth.

Transmission of Television by Satellites

The Rebroadcast Satellite. Thus far in the discussion of alternative transmission media, satellites are posed as an alternative to other bulk or "trunk" transmission systems in which the traffic is collected at the production center and shipped to broadcast stations. In the initial development of the instructional system, satellites are called merely to provide an alternative to transmission by microwave. One or more of the earth stations will beam video programs through a satellite to other earth stations that will hand it over to broadcast stations for local area transmission.

Direct Broadcast Satellite. To increase the area of coverage, the antenna of the broadcast source must be elevated, either by transmitting from a plane or from a satellite. However, accumulated experience strongly suggests that the transmission of video material from a plane is many times more expensive than transmission from a satellite--so much so that this alternative was eliminated from the analysis.

The direct broadcast satellite may be one of two varieties, depending on whether or not the television receiver is to be modified. The least expensive variation (from the aspect of reception costs) uses the conventional receiver and antenna. To reduce overall system costs, a more sensitive receiver and a more expensive antenna may be preferable, but fundamentally the television set is unchanged. However, use of the conventional set requires a large and costly satellite, because (1) the method of modulation must remain AM (amplitude modulation) to conform to the current set design, and (2) the low gain of the conventional television receiver antenna must be compensated for at the satellite end of the transmission link through increased radiated power. In Working Paper No. 4 in Volume IV of this report, B. R. Stack discusses the technological feasibility of direct broadcast at UHF in the time frame of the study. The conclusion is that this option is not feasible. In the second option of direct broadcasting, the transmission takes place at SHF (a microwave frequency), and the method of modulation is FM (frequency modulation). At SHF, antennas have a higher gain, and frequency modulation results in higher performance for the same radiated power. The receiver must be adapted to receive at SHF, and a special antenna, preamplifier, and feed must be provided. The satellite need not be as powerful as that of the direct broadcasting option described above and thus is feasible in the 1975-1979 time frame.

Method of Approach

Previous studies at the Institute have led to the development of various computer models of satellite systems. Some models were of the generalized type; that is, they were capable of manipulating a large number of inputs and producing designs for many different kinds of satellites. Some were service-oriented and were based on a definition of the service that a satellite was to provide.

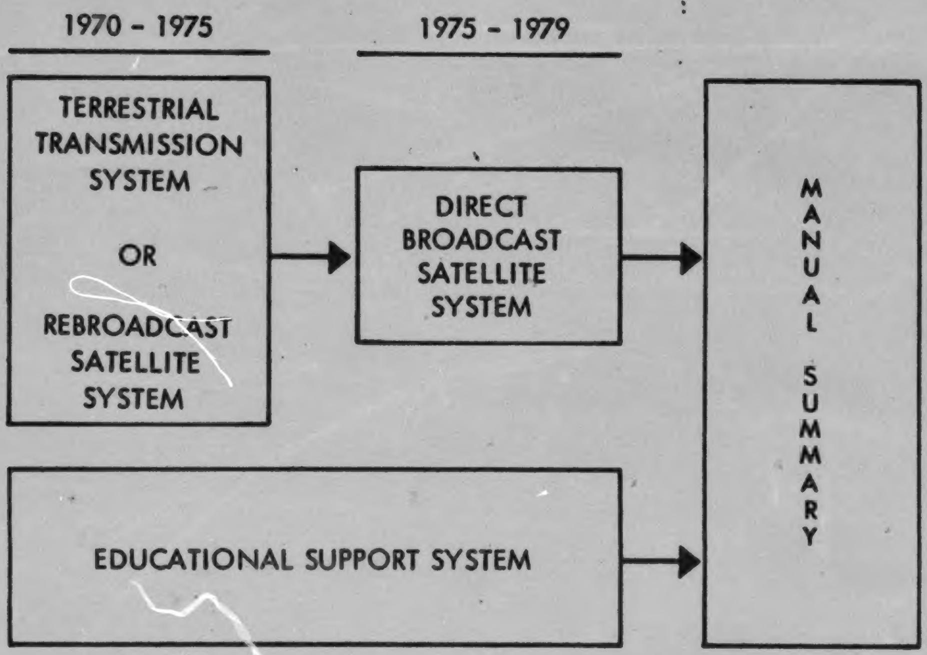
The current study brought together economists,:educators, and engineers. The unanimous adoption of the service-oriented rather than the tool-oriented approach by the entire study team encouraged the engineers to develop special technoeconomic computer models of an instructional system that can "converse" with the educator and inform him about the financial consequences of his demands for quantity and diversity in educational service. If the educator does not like the consequences of the initial request, he can revise his specifications and, minutes later, will receive new information incorporating his changes. The intended result of such man-machine discussions is the optimization of the instructional system (at least in its quantifiable aspects), rather than optimization of hardware. An additional advantage of the service-oriented approach in this study was the capability it provided to optimize separately the specific circumstances of the instructional systems of the two case studies.

The complexity of the problem and the shortage of time prevented the construction of a single computer program that would develop the instructional system through all of its stages. Instead, the economic model consisted of four major and a few minor programs. The first major program calculated the cost of the microwave or the costs of transport to connect the major centers, the cost of tape libraries, and the cost of broadcast stations. The second program interconnected the same centers by means of the rebroadcast satellite. Together, these two programs calculated the costs of the likely first phase in development of the instructional system.

To stimulate the second stage of likely development, a third computer program extended the available coverage by adding a direct broadcast satellite system. The educational costs of production, distribution, and reception for both stages were calculated by the fourth major program. This educational support program was cross-connected with the other three and, at every step, calculated the cost of the educational component corresponding to the hardware component. Figure 1 shows the interrelationship of these programs.

FIGURE 1

SEQUENTIAL RELATIONSHIP OF COMPUTER PROGRAMS


1970 - 1975
1975 - 1979
TERRESTRIAL TRANSMISSION SYSTEM
OR
REBROADCAST SATELLITE SYSTEM
DIRECT BROADCAST SATELLITE SYSTEM
EDUCATIONAL SUPPORT SYSTEM
MANUAL SUMMARY

DESCRIPTION OF THE REBROADCAST SATELLITE PROGRAM

Line Number	Description
10.15	Sets up the matrices to be used in annual cost.
10.2	Opens a file in which the names of individual cost elements are stored.
10.21	Reads from the file.
10.8	Program starts.
11.7	Establishes the initial year of the program run.
10.71	User types in the year (NY).
11.8 - 11.84	Cost elements for seven categories and 10 years are set to zero; program skips to line 37.2
12.8	Asks for the peak-to-peak/RMS noise ratio and the number of video channels; these are given names R and V.
13.3	If the number of video channels is 0, then the video bandwidth is set at 0.
13.35	R1 equals 0 and, correspondingly the video carrier power in dB's is set to a very small value (-250 dBW). The number of program channels accompanying the video (PR) is set to 0. The program skips the video calculations.
13.6	Description of the video channel starts; baseband is set at 5 MHz (5E6); total bandwidth of video is the baseband times the number of video channels.

14.	Program starts a loop in which the peak deviation will be gradually set to higher and higher value, until the peak to peak/RMS ratio requirements are met; starting peak deviation is 1-MHz.
14.4 statement 100	Peak deviation is raised by 1 dB (by multiplying it by 1.1).
14.8	Carsons' rule, bandwidth, is twice the sum of baseband plus peak deviation.
15.2	Frequency modulation improvement, the improvement for a narrow channel in the baseband, is given.
15.6	This is followed by the additional factor of 3 (5dB) due to the triangular distribution of noise across the baseband.
16.	Establishes the minimum required carrier to noise as the user requirement less 18.8 and frequency modulation improvement (18.8 is the sum of pre-emphasis and weighting allowance--2.5 + 16.3--for 625-line picture in a 5 MHz bandwidth).
16.4	Establishes minimum carrier to noise as 15 dB; if the carrier to noise required is larger than 15 dB, then the program is directed to statement 100 and the peak deviation is raised again. The first time it is 15 dB or less, the program continues to the next line (line 110). At that point, the radio bandwidth is converted to megahertz; the video bandwidth is renamed R1; the thermal noise in the bandwidth RB is calculated; and

the video carrier power is set 15 dB higher than the thermal noise.

18.8 User is asked how many PR (program channels per video channel) are needed.

19.6 User has the option of asking for VC (voice channels) for telephony.

20.8 Specifies that the quality in the telephony channel is 45 dB test tone to noise ratio.

21.2 Total baseband is 4 kHz per telephony channel times the number of telephony channels, plus 15 kHz per channel times the number of program channels, plus 12 kHz at the bottom of the baseband.

21.6 Sets up a quantity U=number of equivalent voice channels by dividing the baseband (above the 12 kHz) by 4 kHz; if that number is less than 240 channels, program goes to statement 180, which sets the CCITT loading formula - 1 + 4 times log (number of channels); if the number is 240 or above, the program goes to statement 190, which gives the - 15 + 10 log formula.

23.6 Peak factor is established as 13 dB plus an allowance for the small number of channels. For large number of channels this is approximately 13 dB, and for one channel it is 19 dB; this approximation is considered good enough.

24. Sets up the peak power as the RMS (derived from the loading formula) plus peak factor.

24.4 Program prepares for a loop that will increase the test deviation until the user requirements are met.

Program begins with a test deviation of 10 kHz and raises it in line 24.8 by 1 dB at a time.

25.2 Peak deviation is set up to be the amplitude of a sine wave, the peak power of which is equal to the peak power of all telephone channels.

25.6 Uses Carsons' rule to calculate the total bandwidth.

26. Establishes the modulation index squared by taking the ratio of the test deviation over baseband squared.

26.4 Calculates bandwidth improvement, the radio bandwidth over twice the bandwidth of the voice channel.

26.8 Calculates the product of the two improvements.

27.2 Calculates the thermal noise.

27.6 Calculates the threshold improvement according to Enloe's paper,* which (in effect) says that the radio bandwidth must be larger than either (1) twice the baseband or (2) twice the peak deviation (whichever is the larger); therefore, line 27.6 asks the question: is the peak deviation larger than the baseband? If it is, go to statement 20, which sets the quantity F (filter) bandwidth as equal to the peak deviation; and if it is not larger than the baseband, program goes to statement 22, which sets the filter band F as equal to the baseband.

29.2 Threshold is 10 dB minus the threshold improvement, which is the log of the ratio of radio bandwidth over twice the filter bandwidth; the required carrier power is thermal noise plus threshold;

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* Enloe, L. H., "Decreasing the Threshold in FM by Frequency Feedback," Proceedings of the IRE, 50, January 1962.

signal to noise ratio is threshold, plus the modulation improvement, plus 2.5 dB (weighting factor). If the signal to noise ratio is larger than the requirement (SN), program drops out from the loop; if it is not, it goes to statement 11, which increases the test deviation again.

30.8 Converts the test deviation to kHz.

31.2 Converts the radio bandwidth to MHz and renames it R2.

32. Video power is converted to watts.

32.4 Voice power is converted to watts or a quantity proportional to watts.

32.8 Adds the two powers together.

33.2 Converts the quantity back to dB.

34. Beginning of a program, statement 66. User makes the choice of system noise temperature; system noise temperature is given the name TEMP (it is also given a name of TEMPO, since in the Direct Broadcast version of the program other noise contributions could be added to it).

37.2 Directs the control program to statement 14, which is the beginning of the video bandwidth calculation.

37.6 Marks the point in the program at which both video bandwidth and telephony bandwidth are calculated, and the program continues.

38.8 Radio band is telephony bandwidth plus the number of video channels times the video bandwidth.

40.8 User is asked about the antenna diameter (DIA) and downlink frequency (DFR).

41.6 Calculates the gain of the receiving antenna.

42. User makes a choice of orbit (if a synchronous orbit, H is equal to 1, and the program goes to statement 2, which sets the height in statute miles; otherwise H is as given by the user).

44. Calculates the path loss in two sections as a function of the down frequency and the orbital height.

45.2 User decides on the size of coverage and gives the two sides of a rectangle X and Y; the diagonal is calculated in line 48, then follows the calculation of the antenna beamwidth required of a satellite antenna.

50.8 Converts the beamwidth of the satellite antenna into the satellite antenna gain.

51.2 Calculates the path loss as the isotropic path loss, plus 3 dB allowance for antenna efficiency and minus the sum of the two antenna gains.

51.6 User chooses the number of stations requiring telephony (later these stations are called transmit-receive stations, and the number is given a name ST). User also chooses the number of received-only stations (RST).

52.8 The power required by a satellite to converse with one station is given the name ONEPWR; however, this applies only to telephony, so the voice power is the number of stations times ONEPWR (the miltiple access configuration, where each transmitting earth station uses a part of the total satellite power).

53.6 Distinguishes the video power, which is received by all the users and transmitted by one user, from the voice power (52.8, above).

54.4 Establishes satellite power as the sum of the (voice and video) powers, plus PLOSS, plus 2 dB traveling wave tube margin (this is the limiter back-off).

54.8 Displays satellite output power converted to watts.

56.01 Starts calculations that determine satellite weight, given satellite power, satellite antenna gain, and the number of transponders.

56.01 Establishes a correction factor that varies with time and describes the efficiency of solar cell generation.

56.02 Establishes a correction factor for power tube efficiency that varies with frequency.

56.035 Calculates the numerical value of satellite antenna gain.

56.06 Calculates the weight of the antenna (see Table 1, Figure 2, and Table 2).

56.07 Calculates the weight of the power supply as a function of the radio frequency power required and the two corrections factors, PSF (see Figure 3) and RHO.*

56.075 If the weight of the power supply is less than 50 lbs, then the correction factor .355 is omitted.

56.077 Establishes the weight of a satellite in orbit as the weight of the power supply, plus the weight of the antenna contribution, plus 50 lbs of the basic structure weight, plus the allowance of 5 lbs per video transponder.

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* RHO = DC/RF conversion efficiency of power tubes
= .4 for UHF (500-900 MHz)
and .25 at 4 GHz and up.

Table 1

SATELLITE ANTENNA WEIGHT AS A FUNCTION OF ANTENNA DIAMETER

Weight (lbs)	4 GHz	Diameter (ft)
100		20
	800 MHz	
100		20
280		40
700		60
1,200		80
2,100		100

Source: Based on data developed by NASA.

Figure 2

SATELLITE ANTENNA WEIGHT VERSUS ANTENNA DIAMETER

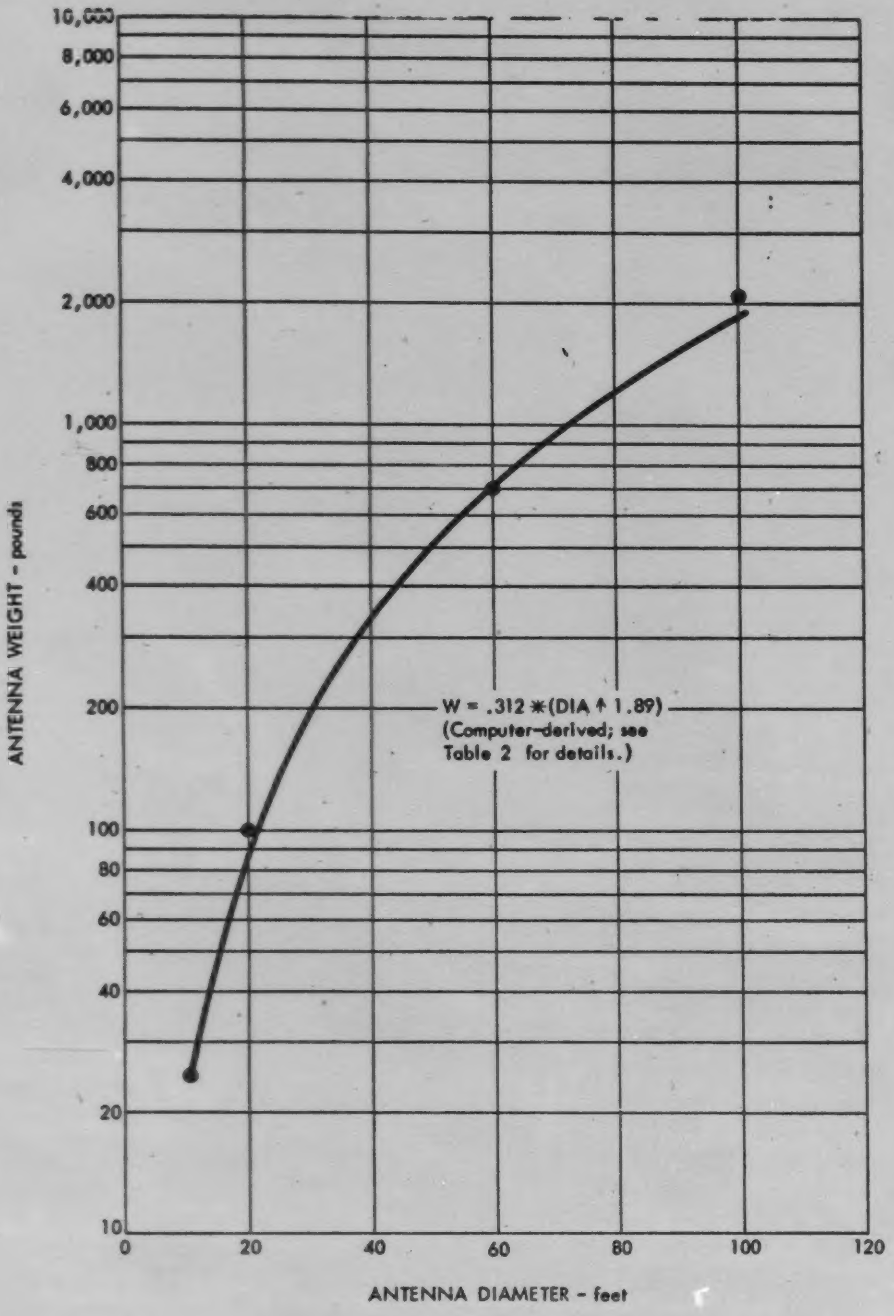


Table 2

SATELLITE ANTENNA WEIGHT VERSUS ANTENNA DIAMETER

LEAST SQUARES CURVES FIT

```
CURVE TYPE          INDEX  OF          A                 B
                 DETERMINATION

1. Y=A+[B*X]      .934062         -600.              24.6
2. Y=A*EXP[B*X]   .977334          56.9892           3.77217 E-2
3. Y=A*[X↑B]      .990575          .312164           1.88969
4. Y=A+[B/X]      .596872          1751.45          -38341.1
5. Y=1/[A+B*X]    .759181          9.79762 E-3      -1.08929 E-4
6. Y=X/[A+B*X]    .995276          .243174          -2.29057 E-3


DETAILS FOR? 3

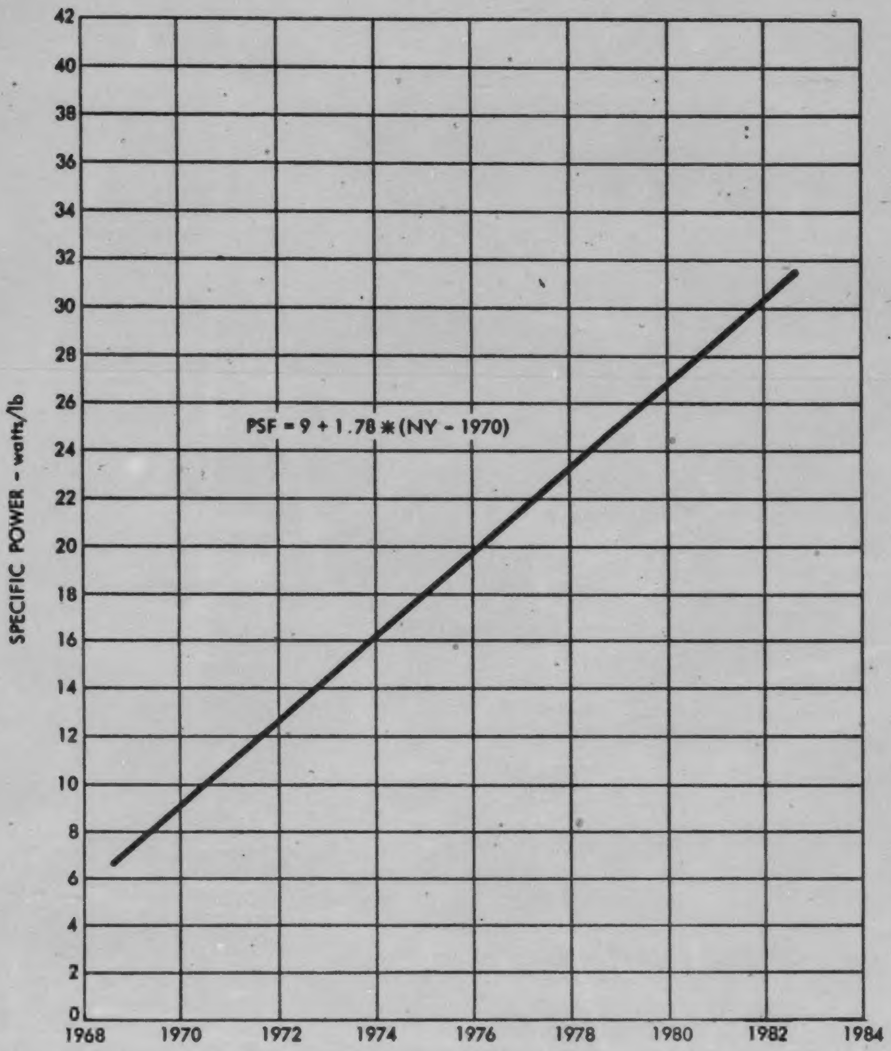
    3. Y=A*[X↑B] IS A POWER FUNCTION.  THE RESULTS
       OF A LEAST-SQUARES FIT OF ITS LINEAR TRANSFORM
       [SORTED IN ORDER OF ASCENDING VALUES OF X]
       ARE AS FOLLOWS:

X-ACTUAL          Y-ACTUAL           Y-CALC          PCT DIFFER

 20                100               89.7282                   11.4
 40                280               332.493         -15.7
 60                700               715.387         -2.1
 90                1200              1232.07         -2.6
 100               2100              1878.31                   11.8
```

Figure 3

EXPECTED IMPROVEMENT IN THE SPECIFIC POWER



56.08 Establishes the launch weight of the satellite as 2.25 times the weight in orbit; launch weight is then displayed (see Table 3).

56.6 - 56.8 The cost of the satellite as a function of satellite weight is calculated and displayed.

58.4 A quantity called HEFT is established (see Table 4). This is the weight of the satellite times the orbital height (in thousands of miles); a series of statements numbered by statements in the 900s follows; a booster is chosen, depending on HEFT. For instance, line 58.8 (statement 901) says: if HEFT is less than 2200, display Booster T.AG.DELTA (Thrust Augmented Delta); the cost of the booster, called BOOSDO is set at 3.5 million dollars; one satellite can be lifted; the number of launches required is 1. If HEFT is less than 2200, the control passes to the collecting point (statement 888). Other boosters are selected in the same way.

65.2 If "lift" is less than or equal to zero, no available booster can lift the satellite and the program is terminated. This can only happen if, in spite of successive upgrading of the power of the booster, the program arrives at the Saturn V and it still cannot lift the satellite. In statement 906 (SATURN V booster) the quantity "lift" is calculated by dividing the actual capability of Saturn V into HEFT. The cutoff point is reached when the lift capability of Saturn V is exceeded by a factor ranging from 1 to 2, thus allowing for advances in satellite technology and possible future modifications to the Saturn V booster.

Table 3

LAUNCH WEIGHT VERSUS WEIGHT IN ORBIT

Booster	Payload (transit orbit)	Useful Spacecraft Weight (lbs)	Ratio
Long Delta DSV-2L-1-364-3	695 lbs	304	2.28
SLV-3A-/Agena	2,266	1,020	2.23
Atlas Centaur	4,100	1,840	2.23
Saturn 1B	5,000	2,250	2.22
Titan III C	9,000	4,050	2.22
Saturn V	110,000	47,000 (60,000)	2.22

Source: Hughes Aircraft data published in Rubin, P.A., "ETV Satellites for Developing Nations," Paper 68-424, presented at AIAA 2nd Communications Satellite Systems Conference, April 8-10, San Francisco, California. Using data provided in this paper, a separated weight of 700 lbs and a final orbit weight of 300 lbs yields a ratio of 2.32.

Table 4

LIFT CAPABILITY OF BOOSTERS

	Lift Capability to Synchronous Orbit					
	Launch Weight in Kg		Launch Weight in Lbs		SRI-Adopted Mean Value in Lbs	
Booster	NASA	COMSAT	NASA	COMSAT		Lbs x 22.3
Thor Delta	210-290	316	560	695	600	13,350
Atlas/Agena/Burner II	1,000	1,030	2,200	2,266	2,200	49,000
Atlas Centaur	1,450	--	3,200			
Atlas/Centaur/Burner II	1,850	1,863	4,060	4,100	4,000	89,000
Titan III C	2,100		4,620			108,000
Titan III C/Transtage/Burner II	3,000	4,090	6,600	9,000	7,800	174,000
Saturn 1B		2,270		5,000		
Saturn 1B/Centaur	8,900		19,600			
Saturn V	47,000	50,000	103,000	110,000	110,000	2,450,000

Sources: Based on data developed by NASA and Comsat Corporation.

66.8 Lift is displayed.

67.2 Starts calculations that determine the required number of satellites to be launched, if the orbit is not synchronous (see Figure 4).

67.6 A quantity called SATS is calculated (by converting to the next higher integer).

68.4 The number of launches is calculated and displayed; however, if the orbit is synchronous, program resumes at statement 24, line 69.6

70.6 Booster cost is displayed.

71.2 The required satellite bandwidth is calculated and displayed (the "voice" bandwidth of one user times the number of stations, plus the video bandwidth of one channel and a guard space of 5MHz times the number of video channels). The satellite bandwidth is then displayed.

72.8 User chooses up-frequency (UFR). Satellite noise figure is assumed to be 6 dB (line 73).

73.1 Satellite receiving antenna gain is assumed to be 17.5 dB.

73.6 Calculates the thermal noise at the satellite input.

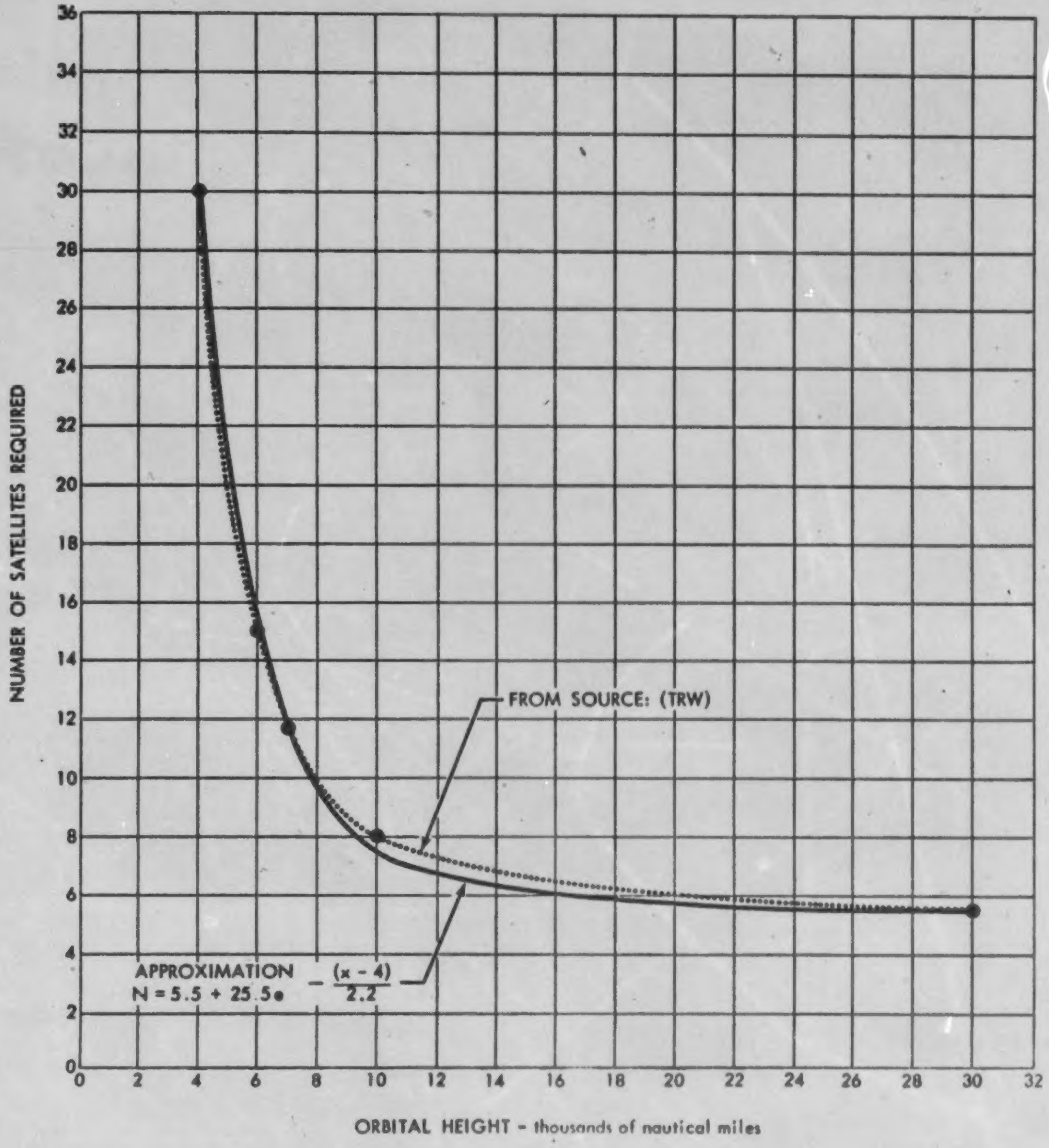
74. The received carrier power required at the satellite input is 12 dB higher than noise, to exceed the FM threshold.

79.4 - 74.8 Calculates the gain of the satellite receive antenna and the up-link loss.

75.2 The 5 dB allowance is to compensate for rain and to provide margin for power control.

Figure 4

NUMBER OF SATELLITES REQUIRED VERSUS ORBITAL HEIGHT
(NONSYNCHRONOUS SATELLITES ONLY)



75.6 The required transmitter power for one channel is calculated and displayed.

78.5 User is given a choice of lifting only one satellite, even if the booster could lift more than one.

78.8 Calculates the launch expense in millions of dollars (the number of satellites times satellite cost).

79 - 79.1 User decides how many channels are used, on the average, in each station. There may be many more video channels in a satellite than are needed by the average station. This quantity is named VA.

79.2 Starts calculating the costs of the earth station equipment; the cost of the baseband equipment is calculated as: number of video channels plus one times 25,000 dollars per video channel.

79.4 The voice receiving equipment is costed at $5,000 plus $1,000 per MHz bandwidth and the video receiving equipment at $25,000 for each video receiver.

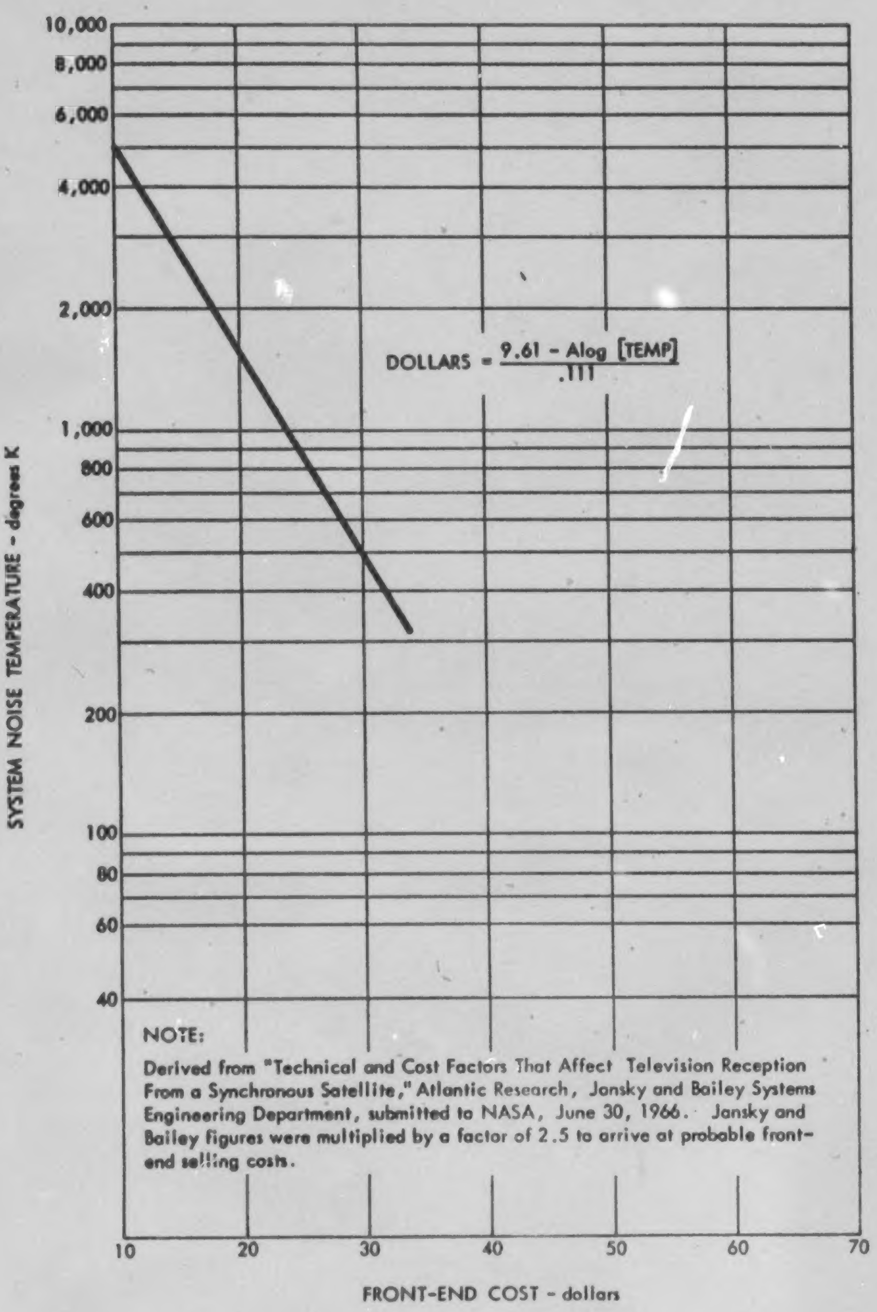
79.6 The cost of the voice bandwidth part of the receivers is separated out.

79.8 A distinction is made between the cost of the front-end at different frequencies by directing the program to line 206 if the frequency is less than 1000 MHz (see Figure 5) and to line 207 if it is more (see Table 5).

80.4 Calculates the equipment cost as a sum of the costs of baseband component, the IF component, and the front-end (in thousands of dollars).

Figure 5

FRONT-END COSTS
(DFR<1,000)



$$\text{DOLLARS} = \frac{9.61 - \text{Alog}\,[\text{TEMP}]}{.111}$$

NOTE:

Derived from "Technical and Cost Factors That Affect Television Reception From a Synchronous Satellite," Atlantic Research, Jansky and Bailey Systems Engineering Department, submitted to NASA, June 30, 1966. Jansky and Bailey figures were multiplied by a factor of 2.5 to arrive at probable front-end selling costs.

Table 5

COST OF RECEIVER FRONT-END, EXCLUDING COST OF LOCAL OSCILLATOR (DFR > 1,000 MHz)

Noise Figure (dB)	Noise Temperature (deg. k)	Cost (dollars)
9	2,000	200
5	626	500
	100	125,000
	70	250,000

Sources: Lenkurt Electric and Page Communications Engineers, Inc.

80.8 If antenna diameter is less than 20 feet, go to statement 451; if it is more, go to statement 452.

80.81 - 80.93 Calculates all antenna costs by curve fitting (see Figures 6 and 7, Tables 6 and 7, and Figure 8).

80.94 For the purpose of calculating procurement costs, a distinction is made between antennas of less than 20 and more than 20 feet in diameter, but this distinction only is used in the Direct Broadcast Satellite program. In the Rebroadcast Satellite program, the quantity named RUN, at which the antennas are assumed to be purchased, is set to 1; in the Direct Broadcast Program the user can decide the number of sets and the quantity purchased at any one time.

81.2 Calculates the cost of transmitting equipment at a basic cost of $500 plus $15,000 times the square root of the transmitter power required (per channel), times the number of video channels, times 3. The factor of 3 is for the 5 dB propagation and signal power control margin allowance discussed above (line 75.2); station dollars (STADO) consists of equipment cost times 1.2 (to allow for installation costs), plus an additional amount (antenna diameter over 100, times 1,000) which represents the installation costs of the antenna. The cost is in thousands of dollars.

83.2 Sets up a quantity called ONE, which is a cost of one station in millions of dollars.

Figure 6

SATELLITE ANTENNA COST VERSUS ANTENNA DIAMETER

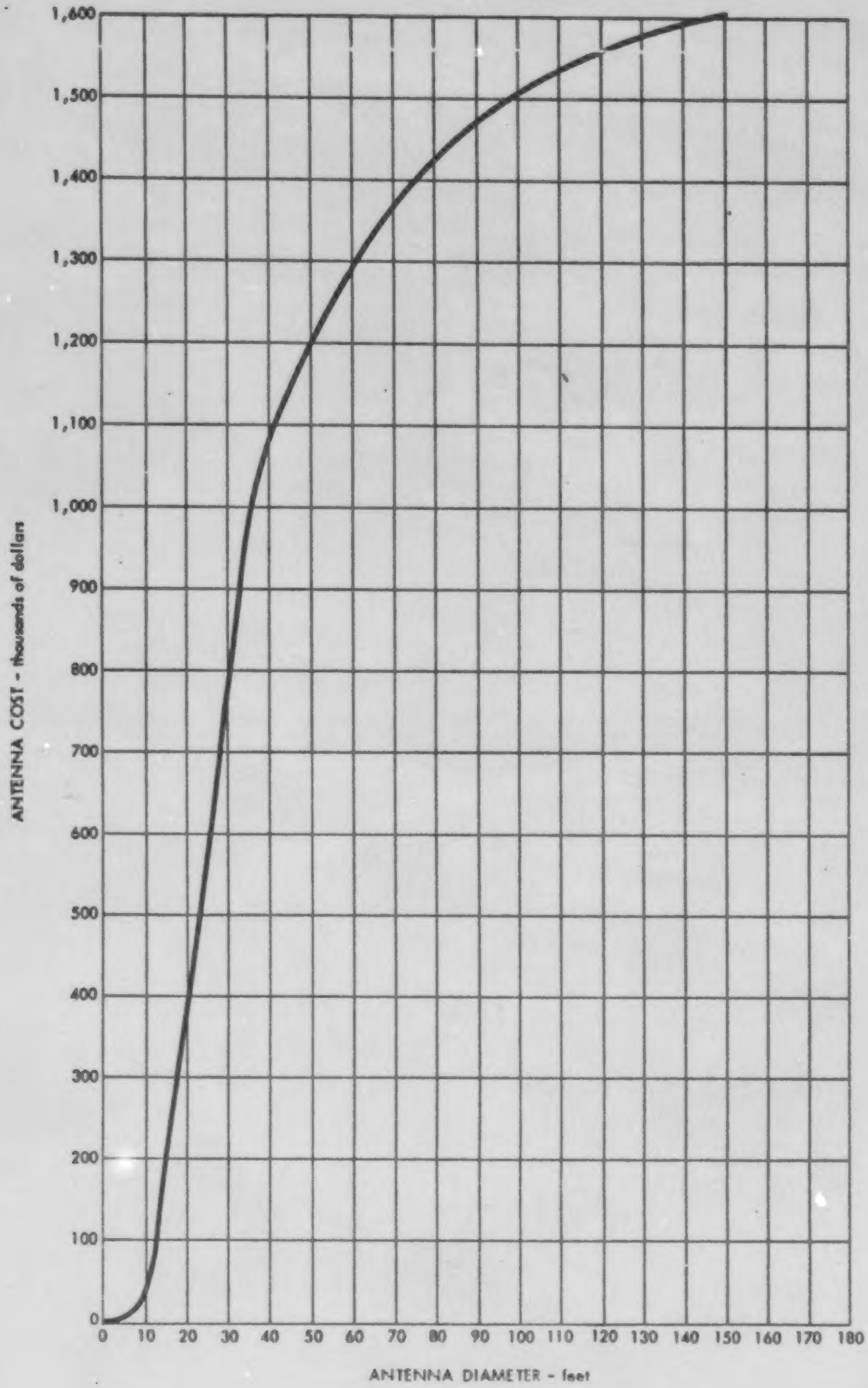


Figure 7

COMPARISON OF ANTENNA COST MODELS

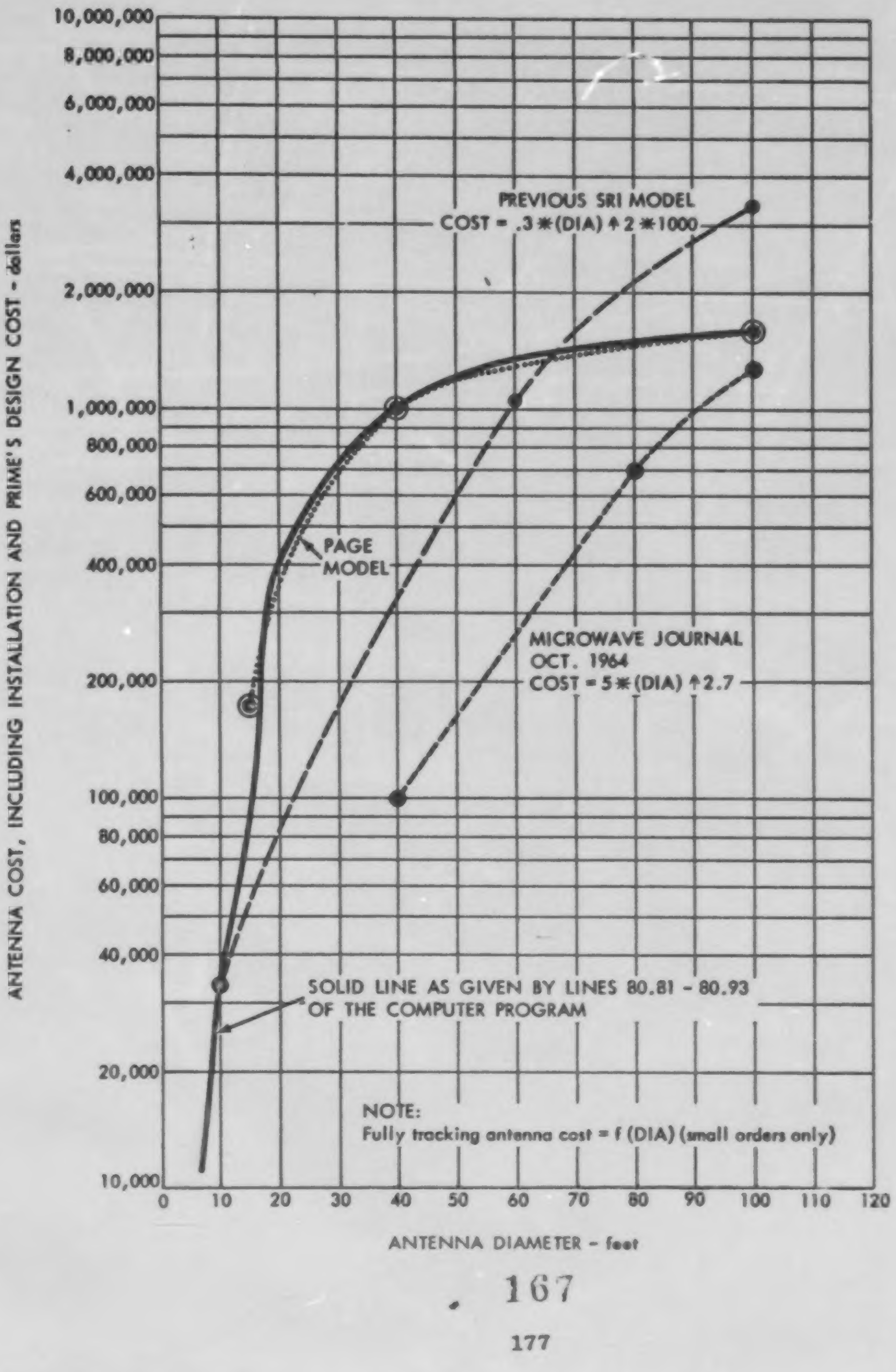


Table 6

ASSUMED ANTENNA COST AS A FUNCTION OF ANTENNA DIAMETER AND OF QUANTITY ORDERED
(Dollars)

Antenna diameter (circled) RUN	QUANTITY ORDERED				
	1	10	100	1000	20,000
10	33198.4	10498.2	3319.8	1049.8	331.9
20	399196.8	126237.1	39919.6	12623.7	3991.9
30	737085.8				
40	994025.8				
50	1181039.0				
60	1313307.5				
70	1405157.2				
80	~~146PE6FF8DH€~~				
90	1511093.8				
100	1540157.6				
110	1559775.2				
120	1572986.4				

Table 7

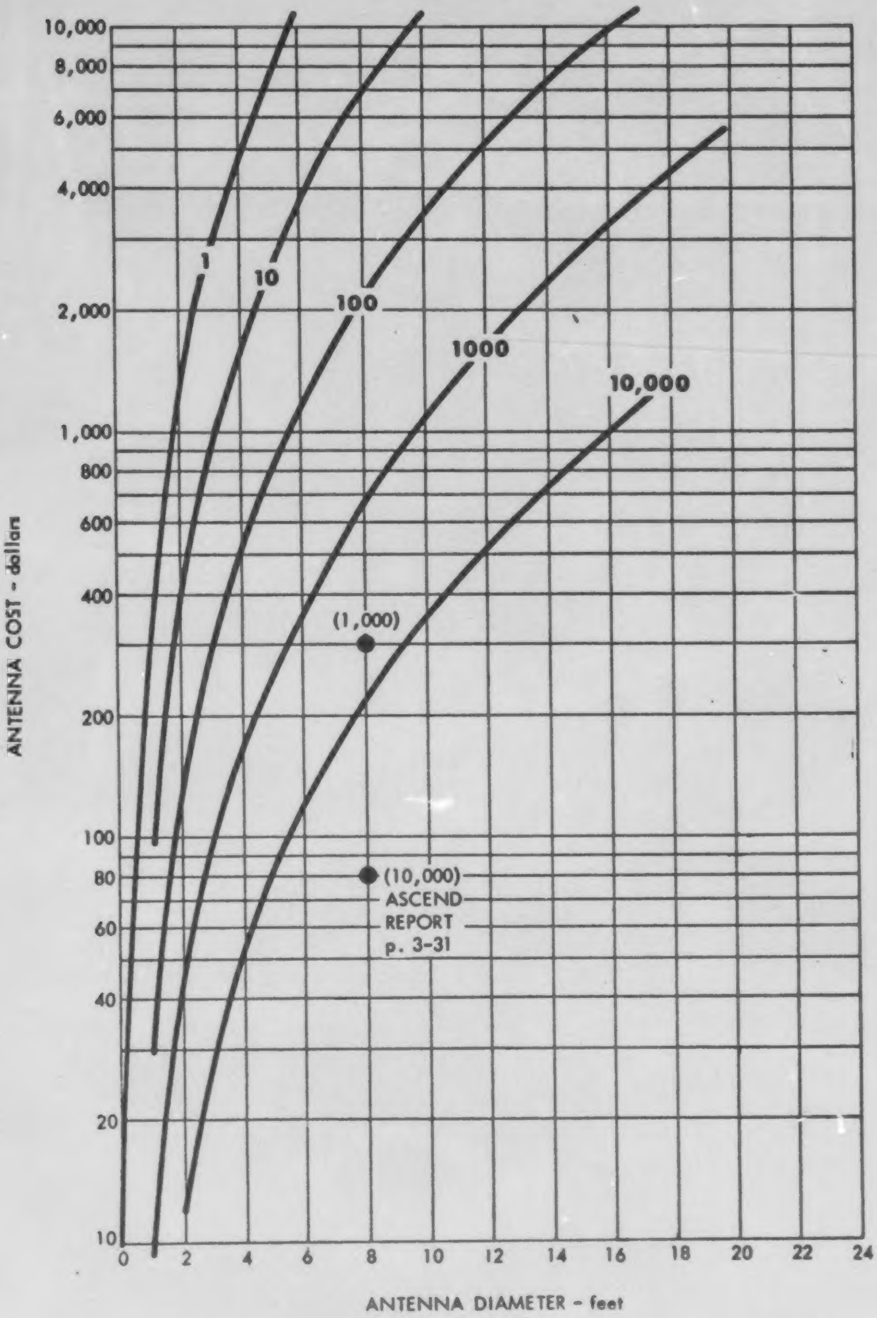
ASSUMED ANTENNA FEED, ANTENNA TRIPOD, AND ANTENNA COST AS A FUNCTION OF DIAMETER AND QUANTITY ORDERED

(Dollars)

Antenna diameter - ft	Q = 1	Q = 10	Q - 100	Q - 1000	Q = 10,000
0	0	0	0	0	0
1	308.634	97.5986	30.8634	9.75986	3.08634
2	1236.91	391.145	123.691	39.1145	12.3691
3	2792.13	882.95	279.213	88.295	27.9213
4	4986.87	1576.99	498.687	157.699	49.8687
5	7839.56	2479.09	783.956	247.909	78.3956
6	11375.5	3597.25	1137.55	359.725	113.755
7	15628.3	4942.11	1562.83	494.211	156.283
8	20641.9	6527.55	2064.19	652.755	206.419
9	26473.6	8371.69	2647.36	837.169	264.736
10	33198.4	10498.3	3319.84	1049.83	331.984
11	40916.	12938.8	4091.6	1293.88	409.16
12	49760.9	15735.8	4976.09	1573.58	497.609
13	59919.9	18948.3	5991.99	1894.83	599.199
14	71661.7	22661.4	7166.17	2266.14	716.617
15	85392.	270[illegible]3.3	8539.2	2700.33	853.92

Figure 8

ASSUMED ANTENNA FEED, ANTENNA TRIPOD, AND ANTENNA COST AS A FUNCTION OF DIAMETER AND QUANTITY ORDERED



83.25 - 83.35	CREW is the costs of station maintenance. It is separated into the costs of foreign personnel (called expatriates) and local personnel (autochtons) in the ratio of 1 to 9.
83.6	Displays the cost of one station, its equipment, and its transmitter part, all in millions of dollars.
84.12	The cost of the receiving station consists of equipment cost plus antenna cost and less the cost of the telephony part of the receiving equipment (RVOI). Identical allocation, as in line 81.6, above, is made for antenna installation.
84.14	The cost of the receive-only station is displayed.
84.4	Sets up the quantity ALL, which is number of transmit-receive stations times ONE and number of receiving stations (RST) times the cost of one receiving station (RSTADO).
84.41	The cost of all stations is displayed.
84.5	Sets up a DO loop in which the costs of additional launches are incurred every three years. The first year of the program is named L (line 11.72).
84.581	Establishes the cost of the first year of the program as the cost of a launch, plus a cost of the additional booster held in reserve, plus the cost of 80 percent of all stations. The second DO loop starting in 84.59.
84.59	Sets costs in category 2 (local country costs) as the remaining 20 percent of all stations. Category 3 and 4 costs are costs of manpower.

85. The total initial system cost (less the reserve booster) is the cost of the satellite plus cost of launch plus cost of all stations. This is displayed as total system costs (millions of dollars).

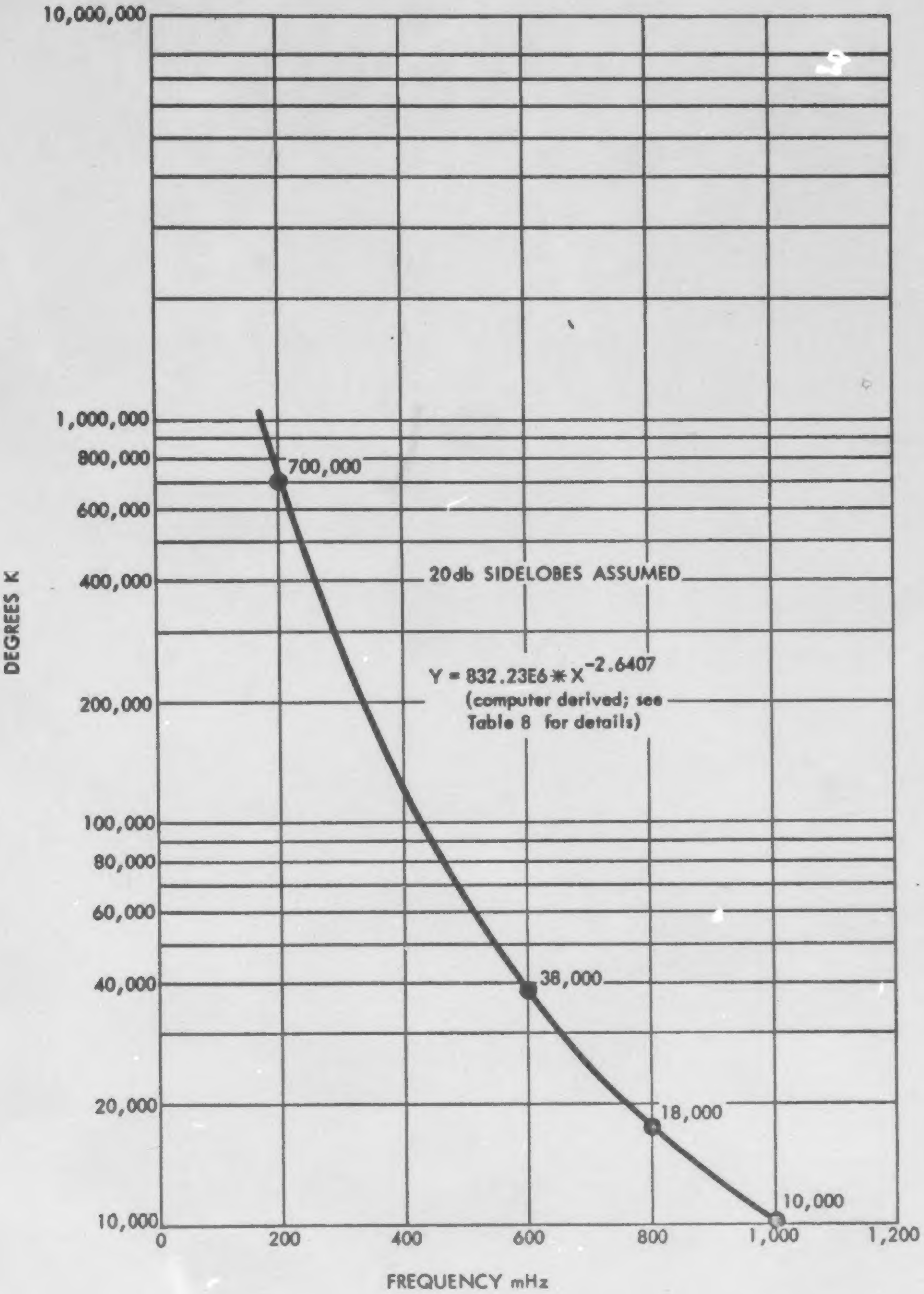
86.1 Directs the control to segment RESULTS in which the categories are summed up and displayed.

STATEMENTS IN THE DIRECT BROADCAST PROGRAM THAT DIFFER FROM THOSE IN THE REBROADCAST PROGRAM

Line Number	Description
12.05	Asks the user to specify the receiver noise figure in dB and at line 12.11 converts the noise figure to the receiver temperature.
12.17	User is asked to specify the receiver environment; the intention is to allow for more than a normal amount of noise for receivers operating at a frequency of less than 1,000 MHz. If the environment is countryside, then 50° of indigenous noise is added to the effective noise temperature of the receiver. For suburbs the figure is 200°, and for the cities it is 1000° (see Figure 9 and Table 8).
70.9	User is asked to determine the number of receiver stations to be reached at the start (STO) and the end (ST) of the period.
71.3	The rate of growth is established, assuming an expotential increase.
79.	Starts the calculations of equipment costs.
79.2	Establishes a number, K, corresponding to the exponent to the base 2 of the quantity procured (that is, the number of times the quantity is doubled).
80.355	If the down-frequency is not between 1,000 and 6,000 MHz, the cost of the local oscillator is assumed to be zero. If the down-frequency is between 1,000 and 6,000 MHz, the cost of the local oscillator (procured in a quantity

Figure 9

INDIGENOUS NOISE VERSUS FREQUENCY - DIRECT BROADCAST SATELLITE



SOURCE: Reference Data For Radio Engineers, International Telephone and Telegraph Corporation, Fourth Edition (New York, 1957).

Table 8

INDIGENOUS NOISE VERSUS FREQUENCY - DIRECT BROADCAST SATELLITE

```
                    LEAST SQUARES CURVES FIT

CURVE TYPE            INDEX  OF            A                  B
                   DETERMINATION

1. Y=A+[B*X]        .799043           768.514           -.887714
2. Y=A*EXP[B*X]     .958158           1565.81           -5.40116 E-3
3. Y=A*[X↑B]        .999988           832237108         -2.6407
4. Y=A+[B/X]        .987223          -210.784            180464.
5. Y=1/[A+B*X]      .908902          -3.10137 E-2        1.18213 E-4
6. Y=X/[A+B*X]      .628763          -17.9824            8.59106 E-2


DETAILS FOR? 3

   3. Y=A*[X↑B] IS A POWER FUNCTION.  THE RESULTS
      OF A LEAST-SQUARES FIT OF ITS LINEAR TRANSFORM
      [SORTED IN ORDER OF ASCENDING VALUES OF X]
      ARE AS FOLLOWS:

X-ACTUAL            Y-ACTUAL             Y-CALC            PCT DIFFER

 200                 700                 698.116                  .2
 600                 38                  38.3703           -.9
 800                 18                  17.9502                  .2
 1000                10                  9.95774                  .4
```

of one) is assumed to be $300 plus a constant that depends on the frequency (see Figure 10).

The cost of other receiver equipment is assumed to be $200 plus the cost of local oscillator ($200 represents the cost of the mixer bought in a quantity of one).

80.402 If the number of program channels per video is greater than one, an additional $100 is allowed for a separate sound receiver that would offer an option of different sound channels with a given video.

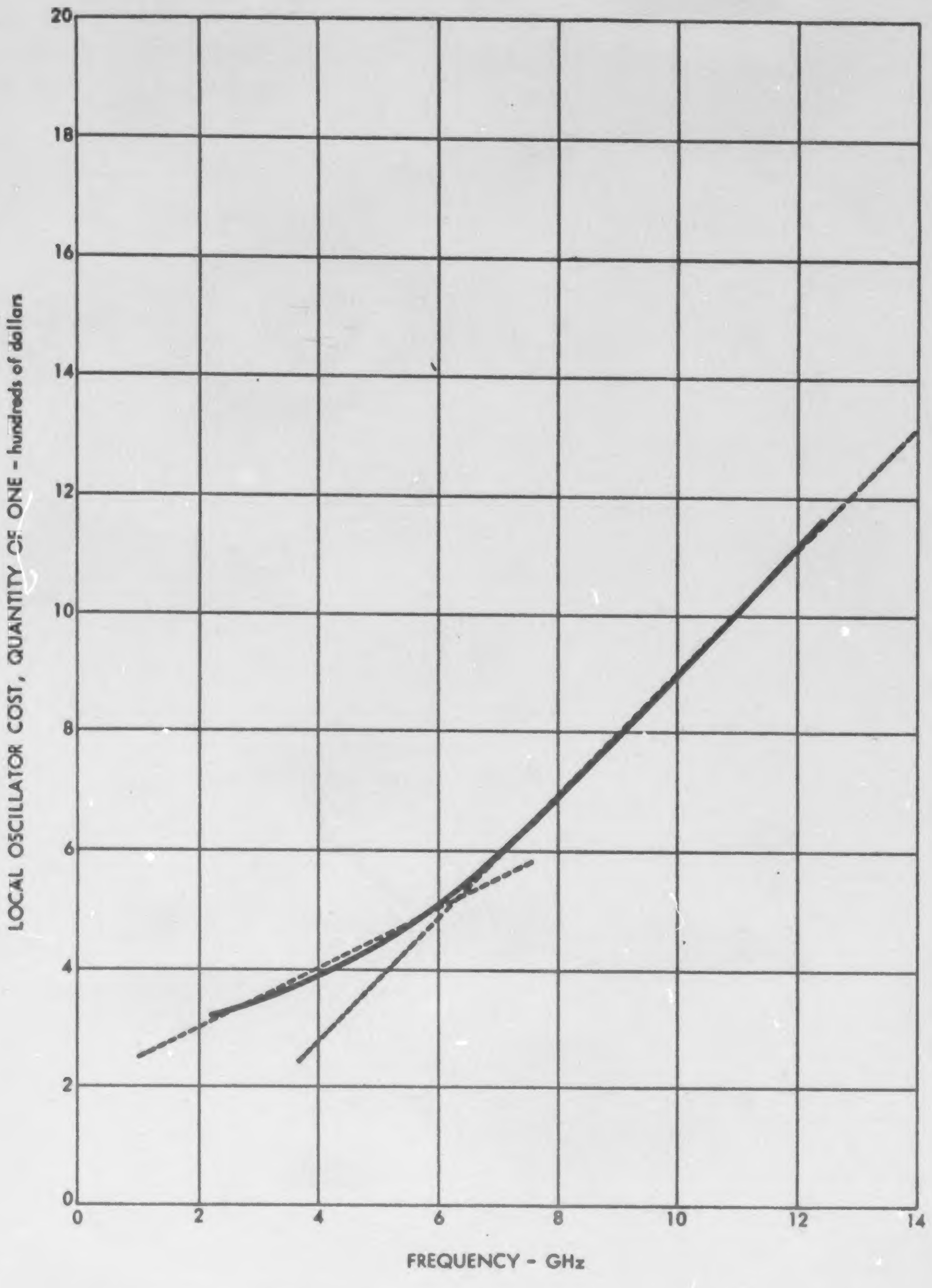
80.406 The equipment cost is multiplied by .85 raised to the power N, with N (established at line 79.22, above, as the number of times a quantity was doubled). Thus, the factor of .85 defines the "learning curve of .85." The cost of the front-end of the receiver is similarly reduced in cost at line 80.31.

80.94 A variable named RUN is defined as a square root of the receiving stations at the end of the period. The statement presupposes that the entire procurement of antennas would be given to one supplier for the whole period.

80.942 However, the user can override the above assumption and divide the procurement among many suppliers. Note that the distribution of quantity among more than one supplier applies only to antennas. The costs of the front-end (mixer and local oscillator) have already been reduced, depending on the total quantity purchased (line 90.406).

Figure 10

COST OF LOCAL OSCILLATOR - DIRECT BROADCAST SATELLITE



SOURCE: Jansky and Bailey, June 1966.

80.965 - 80.975	The costs of the antenna and the preamplifier are displayed.
83.6	The cost of an entire station is displayed.
84.591	Accepts the annual salary (SA) and the transportation expense (TR) of the maintenance technician and, using the receiver growth rate determined previously, determines the costs over a 10-year period for categories 2, 3, and 4 (local hardware, foreign manpower, and local manpower).
84.72	Category 2 costs are subtracted from the costs of the previous year, to determine the costs attributable to one particular year.

DESCRIPTION OF EDUCATIONAL SUPPORT PROGRAM

Note: In this program many categories of names are read from the files; these are categories that, later on, were found not applicable and were replaced by others. A shortage of time did not permit the removal of discarded categories.

Line Number	Description
11.71	The first year of the program is called NY.
18.4 - 18.49	Various variables are set to 0.
18.5	User names the year in which program is to start.
18.74	User types the number of hours of program generated per week at the beginning and at the end of the program, these variable are named HOURS of the appropriate year.
18.99	User is asked to specify the dollar cost of one hour or a new program.
19.029	Sets SPAN as the number of years the program is going to run.
19.03	Establishes the rate at which the number of program hours generated is increasing, based on the assumption of an exponential growth.
19.1	Personnel costs are calculated from hourly costs, and on the assumption that personnel will be employed for 52 weeks a year, the factor 3 accounts for the fact that only one-third of the hours broadcast are generated each year.

19.3 - 19.46 Calculates, year by year, the number of people employed in program production. The variable called FRESH is the number of new hours generated; OLD is the number of hours available from last year's production; LUNIT is a convenient program package consisting of 15 hours of program material, and the number of people in each of the 22 categories is calculated as a function of this LUNIT.

19.42 Similarly the number of studios is calculated on the assumption that each studio can generate one LUNIT a week.

30. - 33. Sets the annual costs for 10 years and 7 categories at 0 prior to processing.

52.9 Displays the number of studios needed to supply the initial number of program material.

53.2 Calculates the cost of studios.

53.5 This calculation is based on the assumption that equipment costs $191,830 per studio;* the information is displayed; building costs of the studio are based on a cost of $5.00 per square foot and on 15,000 square feet per studio.

54.2 The result is displayed.

54.4 Total studio costs consist of the cost of equipment, plus the cost of building.

54.7 The cost is displayed.

---

* Schenkkan, Robert, Thos. Livingston, Vernon Bronson, and William Kessler, *The Feasibility of Using Television for Educational Development in El Salvador* (Prepared for the United States Government, Agency for International Development, Washington, D.C.) National Association of Educational Broadcasters, July 1967

54.8 - 56.45	Calculates components of studio costs, such as: equipment costs, building costs, amortization costs of equipment (based on five-year equipment life), amortization costs of building (based on 30-year building life), maintenance costs of equipment (10 percent of annual costs of equipment), and maintenance of building (5 percent of the annual cost of building). All of these costs are then added.
56.46	The total is displayed.
56.5	User types in the number of television sets expected at the start and at the end of the program.
56.53	The number of sets in each year is calculated on the assumption of exponential growth.
56.56	This number is stored in array SETS.
57.71	User types in the yearly salary of a teachers' instructor.
57.74	User types in the yearly salaries and travel costs of set maintenance technicians, (variables named SA, TEC, and TRA).
58. - 62.2	Calculates the annual costs of production and distribution (personnel costs are category 1).
59.5	Calculates the number of new sets coming into service each year.
59.8	The number of teachers taught times the number of weeks is established as follows: the number of sets times 1.8 teachers per set, times eight weeks of indoctrination course (new teachers entering the program for the first time) plus the number of sets in the previous year, times 1.8 teacher per set, times two weeks of refresher course (for teachers already in the program).

60.1 The number of teachers' instructors is calculated on the assumption that one instructor will teach 40 teachers 40 weeks per year; as a result, the variable WORKINSTR gives the number of instructor years.

60.7 The cost category 4 translates the number of instructor years into the annual costs of instructors, by multiplying the number of instructor years by the annual salary of a teachers' instructor.

61.9 The annual costs of field research workers are calculated on the assumption that one field researcher can visit 80 sets per year and that one-tenth of his salary and travel expense could properly be allocated to the educational system.

61.91 The first part of the above calculation is used to find the number of field research workers needed.

66.7 - 67.6 Other categories of cost are calculated.

67.003 The number of sheets of paper needed is calculated assuming: three sheets of paper per set per hour of programming, times 40 weeks per year, times three copies of the instructional material; the number of sheets is then reduced to 30 percent by assuming that only 30 percent of the classes would require paper support. The printing set-up cost and the cost of printing are calculated on the basis of $17.00 of set-up time and $17.00 press printing time per 100,000 sheets.

67.11 These two cost components are added as category 5, on the assumption that 100,000 sheets of paper cost $200.00.*

67.4 The costs of all categories are added and displayed.

69.4 - 69.7 The number of sets in use is displayed; the cost of set upkeep is calculated, with the assumption that one technician can take care of 400 sets.

71.46 The cost is then calculated (for convenience, the array SETS are used twice, once for calculating the number of sets and once for calculating the salary).

72.2 - 72.6 The sum is updated.

73.3 The cost of sets is displayed.

74.2 The titles of various categories of people participating in the Educational Support Program are read from file. The staffing requirements are displayed in line 79.11, and line 79.13, and line 79.4.

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* Based on data supplied by Lenkurt Electric Publications Department.

THE TERRESTRIAL PROGRAM

Line Number	Description
10.56 - 10.64	The array containing the coordinates of the towns is set at 0.
12.06	Coordinates of all the towns in the region (S. America or India) are read from the file.
12.22	Names of up to 15 main centers (towns originating program material) are read from the file.
12.225	Names of up to 60 towns that will broadcast, but not originate, are read from the file.
12.24	Names of all the towns in the region are read from the file.
12.3 - 12.36	Coordinates of all the towns in the region are converted from minutes to decimals of a degree.
13.24	Names of all the towns in the region are displayed.
13.253	User selects the starting point and the number of towns to be linked.
13.256	User types in the names of the towns he has selected.
13.26 - 13.275	Names and the coordinates of the towns user has selected are put in a separate storage.
13.279	The choice of the towns is confirmed before further processing.

13.29	A warning bell (MANY) is set that will later indicate that the end of network is approaching.
13.36 - 13.388	The rest of the array, containing towns that are not needed, is set to 0.
13.4 - 14.041	Various variables are either set to 0 or a high value before further processing.
17.042	Subroutine RESHUFFLE is called up. To follow the logic of the program, at this point it may be easier for the reader to go directly to the various subroutines. Lines at which these subroutines start are indicated by asterisks.
17.41 - 26.	The shortest distance between any two towns in the selected set is calculated, using spherical trigonometry.
36.	Subroutine BESTPATH is called up.
37.4	Subroutine MICROWAVE is called up.
38.	Control passes to the nearest or next-nearest town.
40.1	The program returns to subroutine RESHUFFLE.
50. *	Subroutine RESHUFFLE.
54.5	The name of each town in the matrix is examined to check if its name corresponds to the name given by the user as a starting point; when the names coincide, both the coordinates and the names of all the selected towns are rearranged, with the starting point being in the first position.
61. *	Subroutine VIDEOTAPE is called up.
61.65	Calculates the costs of transport by truck.

61.8 Checks, if the town is currently under scrutiny, TOWN (OR), is a main center; if it is, program passes to statement 616.

62.1 Checks if the town currently under scrutiny is not a main center (a subcenter or a town merely requiring a broadcast station); if it is such a town, control passes to line 618.

62.5 Checks if the nearest or next nearest town TOWN (WHICH), is not a main center; if it is a subcenter (category 2 town), control passes to statement 620.

63.1 Checks if the TOWN (WHICH) is a main center; if it is a main center, control passes to statement 622.

63.4 Asks how many hours are generated at the town under scrutiny, sets up a variable, STORE, as 13 weeks of storage of video tape, costed at $49.00 per hour.*

63.6 To the cost of videotape is added $2,000 for air-conditioning equipment (the cost of the building containing the library is not included).

63.8 If the number of connections set up is less than the number set by the user by means of the warning bell, MANY, control passes to statement 609; but if the count reaches MANY, the end of the run is approaching.

64. User is asked how many hours of program material per week are generated in the town under scrutiny.

---

* Data supplied by Ampex Corporation.

64.1 STORE is calculated as the number of hours per week generated at the subsidiary center plus 33 hours (per week per channel) worth of tape, times the number of video channels transmitted between the two towns. The average number of hours of programming broadcast over one video channel a week is considered to be 33 hours. The amount of tape stored is equivalent to 13 weeks, times the number of program hours per week, times the number of video channels at the cost of $49.00 per hour of tape.

64.3 Calculates the library generated by the subcenter.

64.4 The count (that is, the number of connections established so far) is updated.

64.46 If the count hasn't yet reached the warning bell stage, control passes to statement 609, but if the end is at hand, the user is warned that this may be the last station in the chain and is instructed accordingly.

64.6 Checks the next town against the list of subsidiary centers and, if the names coincide, control passes to statement 679.

64.68 Establishes a tape library at a cost of $49.00 per hour of programming, times 33 hours per week per one video channel connecting the towns, times the storage time of 13 weeks. As before, $2,000 is added to the cost of tape library for air-conditioning.

64.845 The cost of the library is displayed.

70. * Subroutine SUMMARY.

72.12 Calculates the annual cost of microwave as 15 percent of the first cost.

72.4 Displays the towns between which the link is being built, the cost of broadcast stations, number of video channels broadcast, microwave costs, annual cost of microwave, annual cost of tape transport, and annual cost of tape library. (The above costs are calculated by the subroutine MICROWAVE, which starts at line 91. The reader may prefer to refer to that section of the program before proceeding further.)

72.91 User is given the option of including these numbers in the
72.97 cost summary.

73.4 Cost categories are established.

73.65 If the tape library contains tape, the annual cost of running it is set at $6,000.

73.669 User decides if the town under scrutiny is indeed the last town in the chain and, if it is, only the broadcast station and the library costs are included in the summing-up of costs.

73.7-
73.89 The six cost categories are updated to provide an up-to-date
74.13 summary, which is displayed.

80. * Subroutine BESTPATH.

83.4 The distance between the two towns is compared with the numbers in array containing the preempted distances, to check if the same path has been traversed.

83.6 The paths not yet traversed are then organized into an array called PATH.

83.9	Applies only if the program is going through the calculations for the second time.
84. - 84.3	Selects the shortest path from all of the paths available.
87. - 89.	Finds the distance corresponding to the shortest path (BESTPATH).
89.2 - 89.3	Displays the two towns that are nearest to each other.
89.8 - 90.2	The path that has been selected above is given a value of 25,000 (miles) so as not to be selected again as the shortest; S1 is a switch that tells how many times the BESTPATH route was traversed. BESTPATH could be traversed twice; once to select the shortest path and again to select the next shortest. If the user opts to connect to the next-nearest town, control is passed to statement 82.
91. *	Subroutine MICROWAVE.
91.199	Program asks if there is an ETV station in the town under scrutiny; following lines ask how many video channels are going to be broadcast and how many video channels are needed between this town and the next town.
91.35	In towns where there already is an ETV station, the cost is $100,000 for strengthening the mast of the existing station and for adding antennas plus $413,000 for each video channel.
91.325	If there is no ETV station (in the town), the station costs $545,000 plus $413,000 for each additional video channel.

91.4 Program asks if there is TV-microwave link between the two towns.

91.9 Establishes the number of hops using a ratio of 25 miles per hop. Microwave cost is assumed to be $250,000 per hop plus $30,000 for each video channel to be transmitted;* if the microwave link is already installed, the cost is only $30,000 per video channel.

92.125 The distance between the two towns is included in the array of preempt distances, so that the program does not traverse that path again.

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* Data supplied by Lenkurt Electric.

```
>LIST

 10.               DISPLAY" "
 10.1              COMMON COSTS(7,10),CATEG(7)
 10.15             DIMENSION PAYMENTS(10)
 10.2              OPEN[3,/NAMES/,INPUT,SYMBOLIC]
 10.21             READ (3,1004) (CATEG(K),K=1,7)
 10.22       1004  FORMAT(7A6)
 10.3              CLOSE(3)
 10.31       2000  FORMAT(3F7.3)
 10.4              P=3.14159
 10.8              DISPLAY("A.J.LIPINSKI  STANFORD RESEARCH INSTITUTE")
 11.2              DISPLAY("THE REBROADCAST INSTRUCTIONAL SATELLITE")
 11.6              DISPLAY" "
 11.7              DISPLAY"TYPE IN THE YEAR IN WHICH PROGRAM IS TO START"
 11.705            DISPLAY"ANY YEAR FROM 1970 TO 1979"
 11.71             ACCEPTNY
 11.72             L=NY-1969
 11.8              DO 33, M=1,10
 11.81             DO 34,N=1,7
 11.82             COSTS(N,M)=0
 11.83         34  CONTINUE
 11.84         33  CONTINUE
 12.               GO TO 66
 12.4          14  CONTINUE
 12.8              DISPLAY("REQUIRED PEAK TO PEAK/RMS RATIO,NO OF VIDEO CHANN
                   ELS")
 13.               DISPLAY"EXAMPLE 50,3  (45=ACCEPTABLE,50=GOOD,55=EXCELLENT)
                   "
 13.2              ACCEPTR,V
 13.3              IF(V)411,411,412
 13.35        411  R1=0
 13.4              VICARRIER POWER=-250
 13.42             PR=0
 13.45             GOTO 413
 13.5         412  CONTINUE
 13.6              B=5E6
 13.8              BVI=B*V
 14.               PD=1E6
 14.4         100  PD=PD*1.1
 14.8              RB=2*(B+PD)
 14.9              RBVIDEO=RB
 15.2              EXTRA=10*ALOG10[RB/(2*B)]+20*ALOG10[1.42*PD/B]
 15.6              EXTRA=EXTRA+5
 16.               CN=R-18.8-EXTRA
 16.4              IF(CN-15)110,110,100
 110 CONTINUE
     RADIOBAND=RB/1E6
     R1=RADIOBAND
     XKTB=-228.6+10*ALOG10[RB*TEMP]
     VICARRIER POWER=XKTB+15
     DISPLAY("NUMBER OF PROGRAM CHANNELS PER VIDEO")
     DISPLAY"ONE FOR EACH MAJOR LANGUAGE?"
     ACCEPTPR
 413 CONTINUE
     DISPLAY("NUMBER OF VOICE CHANNELS FOR OTHER USES")
     ACCEPT VC
     VR=45
     B=4E3*VC+15E3*PR+12E3
     BV=B
     U=(B-12E3)/4E3
     IF(U-240)180,180,190
 180 RMS=-1+(4*.4343)*ALOG[U]
     GO TO 16
 190 RMS=-15+4.343*ALOG[U]
  16 PF=13+6/U
     PP=RMS+PF
     TD=1E4
  11 TD=TD*1.1
     PD=TD*SQRT[EXP[PP*.2302]]
     RB=2*(PD+B)
     XM=(TD/B)↑2
     FR=RB/6200
     EXTRA=4.343*ALOG[FR*XM]
     XKTB=-228.6+4.343*ALOG[RB*TEMP]
     IF(PD-B)22,20,20
  20 F=PD
     GO TO 77
  22 F=B
  77 T=10-4.343*ALOG[RB/(2*F)]
     RXCARRIER POWER=XKTB+T
     SN=T+EXTRA+2.5
     IF(SN-VR)11,11,10
  10 TD=TD/1000
     RADIOBAND=RB/1E6
     RBVOICE=RB
     R2=RADIOBAND
     VI=EXP[VICARRIER POWER]
     VO=EXP[RXCARRIER POWER]
     TOTPWR=VI+VO
     TOTAL POWER=ALOG[TOTPWR]
     GO TO 44
  66 CONTINUE
     DISPLAY("TYPE-IN SYSTEM NOISE TEMPERATURE IN DEGREES")
     DISPLAY"80 IS INTELSAT STANDARD,300 IS CHEAPER,1000 PASSAB
     LE"
```

```
36.8            ACCEPTTEMP
36.9            TEMPO=TEMP
37.2            GOTO 44
37.6         44 CONTINUE
38.8            RADIOBAND=R2+V*R1
40.        1000 FORMAT(F8.1)
40.4            DISPLAY(" ")
40.8         15 DISPLAY("TYPE-IN ANTENNA DIA FT,DOWNLINK FREQ. MH")
41.2            ACCEPTDIA,DFR
41.6            RXGAIN=8.686*ALOG[P*DIA*30.5*DFR/3E4]-3
42.             DISPLAY("ORBIT-IF SYNCHR.TYPE 1,OTHERWISE HT. IN STAT.MILE
                S")
42.4            ACCEPTH
42.8            IF(H-1)1,2,1
43.2          1 GO TO 3
43.6          2 H=22289
44.           3 XN=3E4/(DFR*30.5)
44.4            DEN=4*P*H
44.8            XISOTR=74.44+8.686*ALOG[DEN/XN]
45.2            DISPLAY("SIZE OF COVERAGE (MILES X MILES) ?")
45.6            DISPLAY("EXAMPLE 1000,4000")
46.             ACCEPTX,Y
47.6        104 SIDE=X
48.         105 SIDE=SQRT[X↑2+Y↑2]
48.4            GAMMA=SIDE/(2*3959)
48.8            ARC=2*(ATAN[(SIN[GAMMA]/((1-COS[GAMMA])+(H/3959)))])
49.2            THETA=(180/3.1415)*ARC
49.6            DISPLAY("THE ANTENNA BEAMWIDTH IS")
50.             WRITE(1,1001) THETA
50.4       1001 FORMAT(F5.1,8H DEGREES)
50.8            SG=10*ALOG10[27000/(THETA↑2)]
51.2            PLOSS=XISOTR+3-RXGAIN-SG
51.6            DISPLAY("TYPE-IN NO OF EARTH STATIONS REQUIRING TELEPHONY"
                )
52.             ACCEPTST
52.1            DISPLAY"NO OF RECEIVE ONLY STATIONS?"
52.2            ACCEPT RST
52.4            DISPLAY(" ")
52.8            ONEPWR=EXP[RXCARRIER POWER]
53.2            VOPOWER=ST*ONEPWR
53.6            VIPOWER=EXP[VICARRIER POWER]
54.             TOVIPOWER=V*VIPOWER
54.4            SATPWR=ALOG[VOPOWER+TOVIPOWER]+PLOSS+2
54.8            WATTS=EXP[SATPWR*.2323]
55.2            DISPLAY("SAT POWER")
55.6            DISPLAY("WATTS")
56.             WRITE(1,1000) WATTS
```

```
56.01          PSF=9+1.78*(NY-1970)
56.02          RHO=.25
56.03          IF(DFR.LT.1000)RHO=.4
56.035         SG=EXP[SG*.2323]
56.055         SDIA=SQRT[SG*((186*5.28*1E6)↑2)/((P↑2)*(DFR↑2)*1E12*.6)]
56.06          WA=.312*(SDIA↑1.89)
56.07          WP=WATTS/(PSF*RHO*.35)
56.075         IF(WP.LT.50)WP=WATTS/(PSF*RHO)
56.077         WORBIT=WP+WA+50+(V*5)
56.08          POUNDS=2.25*WORBIT
56.085         DISPLAY"SATELLITE WEIGHT- POUNDS"
56.086         WRITE(1,1000) POUNDS
56.6           COEF=8+(2/1800.)*(POUNDS-200)
56.8           SATDO=COEF*POUNDS*1E-3
57.2           DISPLAY("SAT COST $MILLIONS")
57.6           WRITE(1,1000)SATDO
58.            DISPLAY(" ")
58.4           HEFT=POUNDS*(H/1000)
58.8       901 IF(HEFT.LT.2200) DISPLAY"BOOSTER T.AG.DELTA"
59.            BOOSDO=3.5
59.2           LIFT=1
59.3           LAUNCHES=1
  .4           IF(HEFT.LT.2200)GOTO 888
 9.6       903 IF(HEFT.LT.13350) DISPLAY"BOOSTER THOR DELTA"
59.8           BOOSDO=5
60.            LIFT=13350/(POUNDS*H/1000)+.5
60.2           IF(HEFT.LT.13350)GOTO 888
60.4       904 IF(HEFT.LT.49000) DISPLAY"BOOSTER ATLAS-AG-BII"
60.6           BOOSDO=8.4
60.8           LIFT=49000/(POUNDS*H/1000)+.5
61.            IF(HEFT.LT.49000)GOTO 888
61.2       905 IF(HEFT.LT.89E3) DISPLAY"BOOSTER ATLAS-CENT-BII"
61.4           BOOSDO=14.2
61.6           LIFT=89E3/(POUNDS*H/1000)+.5
61.8           IF(HEFT.LT.89E3 )GOTO 888
62.            IF(HEFT.LT.174E3) DISPLAY"BOOSTER TITAN IIIC-TRST-BII"
62.2           BOOSDO=18.1
62.4           LIFT=174E3/(POUNDS*H/1000)+.5
62.6           IF(HEFT.LT.174E3)GOTO 888
62.8       906 IF(HEFT.LT.2.45E6) DISPLAY"BOOSTER  SATURN V"
63.            BOOSDO=203
63.1           LIFT=2.45E6/(POUNDS*H/1000)+.5
63.2           LAUNCHES=1
63.4           CONTINUE
64.8           LAUNCHES=1
65.        888 CONTINUE
65.2           IF(LIFT)991,991,28
65.6       991 DISPLAY("NO STD. BOOSTER CAN LIFT YOUR S :")
  .            DISPLAY("TRY AGAIN-REDUCE RQMTS-GOOD LUCK!")
```

```
66.4            GO TO 999
66.8         28 DISPLAY("BOOSTER CAN LIFT"),LIFT,("      SATELLITES")
67.2            IF(H-22289)25,24,25
67.6         25 SATS=5.5+24.5*EXP[-((H/1.15E3)-4)/2.2]+.5
68.             NSATS=SATS+1
68.1            SATS=NSATS
68.4            LAUNCHES=SATS/LIFT+.5
68.8            DISPLAY("NO OF LAUNCHES REQUIRED"),LAUNCHES
69.2            GO TO 27
69.6         24 CONTINUE
70.             SATS=LIFT
70.4            DISPLAY("NOTE-LAUNCH COST INCLUDES TOTAL SAT. COMPLEMENT")
70.5            DISPLAY"UNLESS SPECIFIED (LATER ON),ALSO ONE BOOSTER IS AS
                SUMED IN RESERVE"
70.6            DISPLAY"THE BOOSTER COSTS ($ MILLIONS FOR ONE):"
70.7            WRITE(1,1000) BOOSDO
70.8            DISPLAY("  ")
71.2         27 SBB=(R2*ST)+(5+R1)*V
71.6            DISPLAY("SAT BWIDTH-MH")
72.             WRITE(1,1000)SBB
72.4            DISPLAY(" ")
72.8            DISPLAY("TYPE-IN UP FREQ-MH")
73.             FIG=6
73.1            SATREX=17.5
73.2            ACCEPTUFR
73.3            IF(R1-R2)422,422,423
73.35       422 R=R2
73.4            GOTO 424
73.45       423 R=R1
73.5        424 CONTINUE
73.6            XTBNF=-213.9+4.343*ALOG[R1*1E6]+FIG
74.             RXPWR=XTBNF+12
74.4            UPLOSS=74.44+8.686*ALOG[P*H*UFR*122/3E4]
74.8            UPGAIN=RXGAIN+8.686*ALOG[UFR/DFR]
75.2            UPLOSS=UPLOSS-SATREX-UPGAIN+3+5
75.6            TXPWR=RXPWR+UPLOSS
76.             DISPLAY(" ")
76.4            TXW=EXP[TXPWR*.2323]
76.8            DISPLAY"REQUIRED TX POWER FOR TV TRANSMISSION OF ONE CHANN
                EL -WATTS"
77.2            WRITE(1,1000)TXW
78.4            XLA=LAUNCHES
78.5            DISPLAY"IF ONE SATELLITE IS NEEDED TYPE 1,IF MORE TYPE 2"
78.6            ACCEPT NOYES
78.7            IF(NOYES.EQ.1)SATS=1
78.8            XLADO=(XLA*BOOSDO)+(SATS*SATDO)
79.             DISPLAY"ON THE AVERAGE,HOW MANY VIDEO CHANNELS ARE NEEDED
                PER STATION"
```

```
79.1            ACCEPT VA
79.2            BASEDO=(1+VA)*25
79.4            RECEDO=(5+RBVOICE/1E6)+25*VA
79.6            RVOI=5+RBVOICE/1E6
79.8            IF(DFR-1000)206,207,207
79.81       207 FRONT=1.86E6*(TEMPO↑(-2.159))*1E3
79.82           GOTO 208
79.83       206 CONTINUE
80.3            FRONT=(9.61-ALOG[TEMPO])/.111
80.32       208 CONTINUE
80.4            EQ=BASEDO+RECEDO+FRONT/1E3
80.8            IF(DIA-20)451,451,452
80.81       451 ANGLE=(-90+4.5*DIA)*P/180
80.82           AMPL=400
80.83           S=SIN[ANGLE]
80.84           S1=ABS[S]
80.85           S2=S1↑.25
80.86           S2=-S2
80.87           C1=AMPL*S2
80.88           GOTO 453
80.89       452 ANGLE=(90*(1-EXP[-((DIA-20)/50)]))
80.9            AMPL=1200
  .91           ANGLE=ANGLE*P/180
  .92           C1=AMPL*SIN[ANGLE]
80.93       453 C1=C1+400
80.94           IF(DIA-20)454,454,455
80.945      454 RUN=1
80.95           C1=C1/RUN
80.96       455 ADO=C1
81.             ORG=C1
81.2            TXDO=.5+15*SQRT[TXW/1000]*VA*3
81.201             C:*3 IS FOR A 5DB PROPAGATION AND SIGNAL POWER CONTR
                OL MARGIN
81.6            STADO=(EQ+ORG+TXDO)*1.2+(DIA/100)*1E3
82.             DISPLAY(" ")
82.8            DISPLAY"COST OF ONE TX-RX STATION,ITS RECEIVE AND TRANSMIT
                 EQPT. $ MILLIONS"
83.2            ONE=STADO/1E3
83.25           CREW=.1*ONE
83.3            EXPATRIATES=.1*CREW
83.35           AUTOCHTONS=.9*CREW
83.6            WRITE(1,2000)ONE,(EQ/1000),(TXDO/1000)
84.12           RSTADO=((EQ+ADO-RVOI)*1.2E-3)+DIA/100
84.13           DISPLAY"COST OF RECEIVE ONLY STATION ITS RECEIVE EQPT. AND
                 ANTENNA $ MILLIONS"
84.135          EQ=EQ-RVOI
84.14           WRITE(1,2000)RSTADO,(EQ/1000),(ADO/1000)
84.2            DISPLAY("ALL STATIONS COST $ MILLIONS")
  .4            ALL=ST*ONE+RST*RSTADO
```

```
      WRITE(1,2000)ALL
      DO 68,KJ=L,10,3
      COSTS(1,KJ)=XLADO
   68 CONTINUE
      COSTS(1,L)=COSTS(1,L)+BOOSDO
      COSTS(1,L)=COSTS(1,L)+.8*ALL
      DO 71,JJ=L,10
      COSTS(2,L)=ALL*.2
      COSTS(3,JJ)=EXPATRIATES*(ST+RST)
      COSTS(4,JJ)=AUTOCHTONS*(ST+RST)
   71 CONTINUE
      TOTAL=SATDO+XLADO+ALL
      DISPLAY("TOTAL SYSTEM COST $ MILLIONS")
      WRITE(1,2000)TOTAL
  999 CONTINUE
      CALL RESULTS
      DISPLAY" "
      END


      SEGMENT RESULTS
      COMMON COSTS(7,10),CATEG(7)
      DO 56,IJ=1,10
      DO 56,IK=1,3,2
      COSTS(6,IJ)=COSTS(6,IJ)+COSTS(IK,IJ)
   56 CONTINUE
      DO 59,NN=1,10
      COSTS(5,NN)=COSTS(2,NN)+COSTS(4,NN)
      COSTS(7,NN)=COSTS(5,NN)+COSTS(6,NN)
   59 CONTINUE
      DISPLAY"ANNUAL EXPENDITURES BY CATEGORY AND YEARS $MILLION
      S"
      DISPLAY" "
      WRITE(1,1006) (LK+1969,LK=1,10)
 1006 FORMAT(6X,10I5)
      DO 77, KK=1,7
      WRITE(1,1007) CATEG(KK)
 1007 FORMAT(/,A6,Z)
      DO 78, JJ=1,10
      WRITE(1,1002) (COSTS(KK,JJ))
 1002 FORMAT(9(F5.1,Z),F5.1/)
   78 CONTINUE
   77 CONTINUE
      END
```

```
>LIST

 10.           DISPLAY" "
 10.1          COMMON COSTS(7,13),CATEG(7)
 10.15         DIMENSION SETS(10),DI(10)
 10.2          OPEN[3,/NAMES/,INPUT,SYMBOLIC]
 10.21         READ (3,1004) (CATEG(K),K=1,7)
 10.22    1004 FORMAT(7A6)
 10.3          CLOSE(3)
 10.4          P=3.14159
 10.8          DISPLAY"A.J.LIPINSKI STANFORD RESEARCH INSTITUTE"
 11.2          DISPLAY"THE DIRECT BROADCAST INSTRUCTIONAL SATELLITE"
 11.6          DISPLAY" "
 11.7          DISPLAY"TYPE IN THE YEAR IN WHICH PROGRAM IS TO START"
 11.705        DISPLAY"ANY YEAR FROM 1970 TO 1979"
 11.71         ACCEPTNY
 11.72         L=NY-1969
 11.8          DO 33, M=1,10
 11.81         DO 34,N=1,7
 11.82         COSTS(N,M)=0
 11.821        SETS(M)=0
 11.83      34 CONTINUE
 11.84      33 CONTINUE
 11.9       15 DISPLAY"ANTENNA DIA (FT),DOWNLINK FR MHERTZ"
 11.91         ACCEPTDIA,DFR
 12.           GO TO 66
 12.01      66 CONTINUE
 12.03         DISPLAY" "
 12.05         DISPLAY"TYPE-IN RECEIVER NOISE FIGURE IN DB"
 12.07         DISPLAY"THE RANGE IS FROM 4DB(EXCELLENT) TO 13 DB(POOR)"
 12.09         ACCEPT RXNOISEFIGURE
 12.11         TEMP=((EXP[RXNOISEFIGURE*.2323])-1)*290
 12.13         TEMPO=TEMP
 12.15         DISPLAY"SPECIFY RX ENVIRONMENT"
 12.17         DISPLAY"TYPE (1) COUNTRYSIDE (2) SUBURBS (3)TOWNS"
 12.19         DISPLAY"TYPE HIGHER NUMBER IF MORE THAN ONE INVOLVED"
 12.21         DISPLAY"I.E. TYPE EITHER 1, 2 OR 3"
 12.23         ACCEPT NOISE
 12.25         GOTO (501,502,503) NOISE
 12.27     501 TEMP=TEMP+50
 12.29         GOTO 504
 12.31     502 TEMP=TEMP+200
 12.33         GOTO  504
 12.35     503 TEMP=TEMP+1000
```

```
12.37    504 IF(DFR.GT.890)TEMP=TEMPO
12.8         DISPLAY"REQUIRED PEAK TO PEAK/RMS RATIO,NO OF VIDEO CHANNE
             LS"
13.          DISPLAY"EXAMPLE 50,3  (45=ACCEPTABLE,50=GOOD,55=EXC.)"
13.2         ACCEPTR,V
13.6         B=5E6
14.          PD=1E6
14.4     100 PD=PD*1.1
14.8         RB=2*(B+PD)
15.2         EXTRA=10*ALOG10[RB/(2*B)]+20*ALOG10[1.42*PD/B]
15.6         EXTRA=EXTRA+5
16.          CN=R-15.8-EXTRA
16.4         IF(CN-15)110,110,100
16.8     110 CONTINUE
16.9         IF(DFR.LT.900)CN=R-10.6+3
16.95        IF(DFR.LT.900)RB=15E6
17.          DISPLAY"NUMBER OF PROGRAM CHANNELS PER VIDEO"
17.1         ACCEPTPR
17.2         RADIOBAND=RB/1E6
17.6         R1=RADIOBAND
18.          XKTB=-228.6+10*ALOG10[RB*TEMP]
18.4         VICARRIER POWER=XKTB+15
18.6         IF(DFR.LT.900)VICARRIER POWER=XKTB+CN
20.8         VR=45
21.15        VC=0
21.2         B=4E3*VC+15E3*PR+12E3
21.6         U=(B-12E3)/4E3
22.          IF(U-240)180,180,190
22.4     180 RMS=-1+(4*.4343)*ALOG[U]
22.8         GO TO 16
23.2     190 RMS=-15+4.343*ALOG[U]
23.6      16 PF=13+6/U
24.          PP=RMS+PF
24.4         TD=1E4
24.8      11 TD=TD*1.1
25.2         PD=TD*SQRT[EXP[PP*.2302]]
25.6         RB=2*(PD+B)
26.          XM=(TD/B)↑2
26.4         FR=RB/6200
26.8         EXTRA=4.343*ALOG[FR*XM]
27.2         XKTB=-228.6+4.343*ALOG[RB*TEMP]
27.6         IF(PD-B)22,20,20
28.       20 F=PD
28.4         GO TO 77
28.8      22 F=B
29.2      77 T=10-4.343*ALOG[RB/(2*F)]
29.6         RXCARRIER POWER=XKTB+T
30.          SN=T+EXTRA+2.5
30.4         IF(SN-VR)11,11,10
```

```
  10 TD=TD/1000
     RADIOBAND=RB/1E6
     R2=RADIOBAND
     VI=EXP[VICARRIER POWER]
     TOTPWR=VI
     TOTAL POWER=ALOG[TOTPWR]
     RADIOBAND=V*R1+R2
     DISPLAY"RF BANDWIDTH-MH"
     WRITE (1,1000)RADIOBAND
1000 FORMAT(F8.1)
     DISPLAY" "
     RXGAIN=8.686*ALOG[P*DIA*30.5*DFR/3E4]-3
     DISPLAY"ORBIT-IF SYNCHR.TYPE 1,OTHERWISE HT. IN STAT.MILES
     "
     ACCEPTH
     IF(H-1)1,2,1
   1 GO TO 3
   2 H=22289
   3 XN=3E4/(DFR*30.5)
     DEN=4*P*H
     XISOTR=74.44+8.686*ALOG[DEN/XN]
     DISPLAY"SIZE OF COVERAGE (MILES X MILES) ?"
     DISPLAY"EXAMPLE 1000,4000"
     ACCEPTX,Y
     SIDE =SQRT[X↑2+Y↑2]
 105 CONTINUE
     GAMMA=SIDE/(2*3959)
     ARC=2*(ATAN[(SIN[GAMMA]/((1-COS[GAMMA])+(H/3959))))])
     THETA=(180/3.1415)*ARC
     DISPLAY"THE ANTENNA BEAMWIDTH IS"
     WRITE(1,1001) THETA
1001 FORMAT(F5.1,8H DEGREES)
     SG=10*ALOG10[27000/(THETA↑2)]
     PLOSS=XISOTR+3-RXGAIN-SG
     DISPLAY" "
     ONEPWR=EXP[RXCARRIER POWER]
     ST=0
     VOPOWER=ST*ONEPWR
     VIPOWER=EXP[VICARRIER POWER]
     TOVIPOWER=V*VIPOWER
     SATPWR=ALOG[VOPOWER+TOVIPOWER]+PLOSS+2
     IF((DFR.LT.3700).OR.(DFR.GT.4200))GOTO 611
     G1M=10*ALOG10[4*P*(DFR↑2)/9E4]
     P1M=SATPWR-XISOTR+SG+G1M
     P4KC=P1M+10*ALOG10[4E3/(R1*1E6)]
     IF(P4KC.LT.-152)GOTO 611
     WRITE(1,404)(P4KC+152)
 404 FORMAT(25HFLUX DENSITY EXCEEDED BY ,F4.1,3H DB)
 611 CONTINUE
```

```
54.8                WATTS=EXP[SATPWR*.2323]
55.2                DISPLAY"SAT POWER"
55.6                DISPLAY"WATTS"
56.                 WRITE(1,1000)WATTS
56.01               PSF=9+1.78*(NY-1970)
56.02               RHO=.25
56.03               IF(DFR.LT.1000)RHO=.4
56.035              SG=EXP[SG*.2323]
56.055              SDIA=SQRT[SG*((186*5.28*1E6)↑2)/((P↑2)*(DFK↑2)*1E12*.6)]
56.06               WA=.312*(SDIA↑1.89)
56.07               WP=WATTS/(PSF*RHO*.35)
56.075              IF(WP.LT.50)WP=WATTS/(PSF*RHO)
56.077              WORBIT=WP+WA+50+(V*5)
56.08               POUNDS=2.25*WORBIT
56.085              DISPLAY"SATELLITE WEIGHT- POUNDS"
56.086              WRITE(1,1000) POUNDS
56.6                COEF=8+(2/1800.)*(POUNDS-200)
56.8                SATDO=COEF*POUNDS*1E-3
57.2                DISPLAY"SAT COST $MILLIONS"
57.6                WRITE(1,1000)SATDO
58.                 DISPLAY" "
58.4                HEFT=POUNDS*(H/1000)
58.8            901 IF(HEFT.LT.2200) DISPLAY"BOOSTER T.AG.DELTA"
59.                 BOOSDO=3.5
59.2                LIFT=1
59.3                LAUNCHES=1
59.4                IF(HEFT.LT.2200)GOTO 888
59.6            903 IF(HEFT.LT.13350) DISPLAY"BOOSTER THOR DELTA"
59.8                BOOSDO=5
60.                 LIFT=13350/(POUNDS*H/1000)+.5
60.2                IF(HEFT.LT.13350)GOTO 888
60.4            904 IF(HEFT.LT.49000) DISPLAY"BOOSTER ATLAS-AG-BII"
60.6                BOOSDO=8.4
60.8                LIFT=49000/(POUNDS*H/1000)+.5
61.                 IF(HEFT.LT.49000)GOTO 888
61.2            905 IF(HEFT.LT.89E3) DISPLAY"BOOSTER ATLAS-CENT-BII"
61.4                BOOSDO=14.2
61.6                LIFT=89E3/(POUNDS*H/1000)+.5
61.8                IF(HEFT.LT.89E3 )GOTO 888
62.                 IF(HEFT.LT.174E3) DISPLAY"BOOSTER TITAN IIIC-TRST-BII"
62.2                BOOSDO=18.1
62.4                LIFT=174E3/(POUNDS*H/1000)+.5
62.6                IF(HEFT.LT.174E3)GOTO 888
62.8            906 IF(HEFT.LT.2.45E6) DISPLAY"BOOSTER  SATURN V"
63.                 BOOSDO=203
63.1                LIFT=2.45E6/(POUNDS*H/1000)+.5
63.2                LAUNCHES=1
65.             888 CONTINUE
65.2                IF(LIFT)991,991,28
65.6            991 DISPLAY"NO STD. BOOSTER CAN LIFT YOUR SAT"
```

```
      DISPLAY"TRY AGAIN-REDUCE RQMTS-GOOD LUCK!"
      GO TO 999
   28 DISPLAY"BOOSTER CAN LIFT",LIFT,"      SATELLITES"
      IF(H-22289)25,24,25
   25 SATS=5.5+24.5*EXP[-((H/1.15E3)-4)/2.2]+.5
      NSATS=SATS+1
      SATS=NSATS
      LAUNCHES=SATS/LIFT+.5
      DISPLAY"NO OF LAUNCHES REQUIRED",LAUNCHES
      GO TO 27
   24 CONTINUE
      SATS=LIFT
      DISPLAY"NOTE-LAUNCH COST INCLUDES TOTAL SAT. COMPLEMENT"
      DISPLAY"UNLESS SPECIFIED (LATER ON),ALSO ONE BOOSTER IS AS
      SUMED IN RESERVE"
      DISPLAY"THE BOOSTER COSTS ($ MILLIONS FOR ONE):"
      WRITE(1,1000)BOOSDO
      DISPLAY" "
      DISPLAY"NUMBER OF RECEIVER STATIONS"
   27 SBB=R2+(5+R1)*V
      DISPLAY"TO BE REACHED AT THE START AND THE END OF PERIOD"
      ACCEPT STO,ST
      RATE=(ST/STO)↑(1/(10.-L))
      DISPLAY"SAT BWIDTH-MH"
      WRITE(1,1000)SBB
      DISPLAY" "
      XLA=LAUNCHES
      DISPLAY"IF ONE SATELLITE IS NEEDED TYPE 1,IF MORE TYPE 2"
      ACCEPT NOYES
      IF(NOYES.EQ.1)SATS=1
      XLADO=(XLA*BOOSDO)+(SATS*SATDO)
      DISPLAY"COST OF TUNER OR PRE-AMP BOUGHT IN QUANTITY"
      K=1
      DO 777,N=1,100
      K=K*2
      IF(K.GT.ST)GOTO 778
  777 CONTINUE
  778 CONTINUE
      IF(DFR-1000)206.207,207
  207 FRONT=1.86E6*(TEMPO)↑(-2.159))*1E3
  566 FRONT=FRONT*((.85)↑N)
      GOTO 208
  206 CONTINUE
      FRONT=(9.61-ALOG[TEMPO])/.111
      FRONT=FRONT*((.85)↑N)
  208 CONTINUE
      WRITE(1,1000) FRONT
      COSTLO=0
      IF((DFR.LT.6E3).AND.(DFR.GT.1E3))COSTLO=300+.05*(DFR-2E3)
```

```
80.401        EQ=200+COSTLO
80.402        IF(V.GT.1)EQ=EQ+100
80.406        EQ=EQ*((.85)↑N)+FRONT
80.8          IF(DIA-20)451,451,452
80.81     451 ANGLE=(-90+4.5*DIA)*P/180
80.82         AMPL=400
80.83         S=SIN[ANGLE]
80.84         S1=ABS[S]
80.85         S2=S1↑.25
80.86         S2=-S2
80.87         C1=AMPL*S2
80.88         GOTO 453
80.89     452 ANGLE=(90*(1-EXP[-((DIA-20)/50)]))
80.9          AMPL=1200
80.91         ANGLE=ANGLE*P/180
80.92         C1=AMPL*SIN[ANGLE]
80.93     453 C1=C1+400
80.94     454 RUN=(ST)↑.5
80.941        DISPLAY" "
80.942        DISPLAY"HOW MANY SUPPLIERS WOULD PROVIDE ANTENNAS:?"
80.943        ACCEPT MANY
80.944        RUN=RUN/MANY
80.95         C1=C1/RUN
80.96     455 ADO=C1*1E3
80.965        DISPLAY"COST OF AN ANTENNA BOUGHT IN QUANTITY"
80.966        DISPLAY"DOLLARS"
80.97         WRITE(1,1000) ADO
80.975        DISPLAY"COST OF PRE-AMP AND FEED (DOLLARS)"
80.98         WRITE(1,1000) EQ
81.6          STADO=(EQ+ADO)*1.2
82.           DISPLAY" "
82.4          TOTAL=XLADO+(STADO*STO/1E6)+BOOSDO
82.8          DISPLAY"COST OF ONE STATION $ MILLIONS"
83.2          ONE=STADO/1E6
83.25         CREW=.1*ONE
83.3          EXPATRIATES=.1*CREW
83.35         AUTOCHTONS=.9*CREW
83.6          WRITE(1,1003) ONE
83.61    1003 FORMAT(F10.6)
84.           DISPLAY"INITIALLY THE STATIONS COST ($ MILLIONS)"
84.4          ALL=ONE*STO
84.45         WRITE(1,1000)ALL
84.5          DO 68,KJ=L,10,3
84.54         COSTS(1,KJ)=COSTS(1,KJ)+XLADO
84.58      68 CONTINUE
84.581        COSTS(1,L)=COSTS(1,L)+BOOSDO
84.59         DISPLAY" "
84.591        DISPLAY"TYPE ANNUAL SALARY,TRANSPORT EXPENSE"
84.592        DISPLAY"MAINTENANCE TECHNICIAN"
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84.593         ACCEPT SA,TR
84.6           ST=STO/RATE
84.61          DO 71,JJ=L,10
84.611         ST=ST*RATE
84.612         COSTS(2,JJ)=ONE*ST
84.62          SETS(JJ)=ST
84.65          COSTS(3,JJ)=EXPATRIATES*ST
84.7           COSTS(4,JJ)=(SA+TR)*(ST/100)*1E-6
84.71       71 CONTINUE
84.711         MN=L+1
84.72          DO 72,NN=MN,10
84.74          DI(NN)=COSTS(2,NN)-COSTS(2,(NN-1))
84.78       72.CONTINUE
84.79          DO 73,K=MN,10
84.792         COSTS(2,K)=DI(K)
84.794      73 CONTINUE
85.2           DISPLAY"TOTAL SYSTEM COST $ MILLIONS"
85.6           WRITE(1,1000)TOTAL
85.8       980 FORMAT(F6.1,X)
86.1           CALL RESULTS
86.12      999 CONTINUE
86.15          END
```

```
86.2           SEGMENT RESULTS
86.3           COMMON COSTS(7,13),CATEG(7)
86.35          DO 56,IJ=1,10
86.36          DO 56,IK=1,3,2
86.37          COSTS(6,IJ)=COSTS(6,IJ)+COSTS(IK,IJ)
86.5        56 CONTINUE
86.55          DO 59,NN=1,10
86.56          COSTS(5,NN)=COSTS(2,NN)+COSTS(4,NN)
86.59          COSTS(7,NN)=COSTS(5,NN)+COSTS(6,NN)
86.62       59 CONTINUE
87.            DISPLAY"ANNUAL EXPENDITURES BY CATEGORY AND YEARS $MILLION
               S"
87.1           DISPLAY" "
87.18          WRITE(1,1006) (LK+1969,LK=1,10)
87.19     1006 FORMAT(6X,10I5)
87.2           DO 77, KK=1,7
87.25          WRITE(1,1007) CATEG(KK)
87.26     1007 FORMAT(/,A6,Z)
87.3           DO 78, JJ=1,10
87.4           WRITE(1,1002) (COSTS(KK,JJ))
87.45     1002 FORMAT(9(F5.1,Z),F5.1/)
87.5        78 CONTINUE
87.6        77 CONTINUE
87.7           END
```

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>LIST

 10.            DIMENSION CAT(15,3),SETS(10),HOURS(15)
 10.3           DIMENSION STATION(5,4),PRODUCTION(6,4),PROGRAM(15,5),TITLE
                S(5,3)
 10.6           DIMENSION ANCSTS(7,10),COSTCATEG(7,3),ANCSTS2(7,10)
 10.9           DIMENSION PERSONNEL COSTS(16),PERSONNEL HOURS(5)
 11.            DIMENSION DES(22),SET(10)
 11.1           INTEGER PEOPLE(22,10),STUDIOS(10)
 11.21          DISPLAY"L.MOLL-A.LIPINSKI-STANFORD RESEARCH INSTITUTE"
 11.22          DISPLAY"PROJECT 7150-EDUCATIONAL SUPPORT COSTS"
 11.23          DISPLAY" "
 11.24          DISPLAY"TYPED IN FIGURES MUST BE SEPARATED BY COMMAS"
 11.8           DO 50,IM=1,15
 12.1           HOURS(IM)=0
 12.4        50 CONTINUE
 12.7           OPEN[2,/EDIFILE/,INPUT,SYMBOLIC]
 12.8           READ(2,499)((CAT(K,M),M=1,3),K=1,13)
 12.9       499 FORMAT(10X,2A6,X,I3)
 13.            READ (2,55)((STATION(L,K),K=1,4),L=1,5)
 13.3        55 FORMAT(2A6,F6.2,F2)
 14.2           READ(2,60)((PRODUCTION(L,K),K=1,4),L=1,6)
 14.5        60 FORMAT(2A6,F5.2,F4.2)
 15.4           READ(2,70)((PROGRAM(K,L),K=1,13),L=1,5)
 15.7        70 FORMAT (13F4.1)
 16.6           READ(2,80)((TITLES(L,K),K=1,3),L=1,5)
 16.9        80 FORMAT (2A6,F5.2)
 18.1       100 FORMAT (50(X,I3))
 18.11          READ (2,555)((COSTCATEG(L,K),K=1,3),L=1,7)
 18.2       555 FORMAT (3A6)
 18.4           CLOSE (2)
 18.41          DO 31,J=1,10
 18.412         SETS(J)=0
 18.413         SET(J)=0
 18.416         HOURS(J)=0
 18.422         PERSONNEL COSTS(J)=0
 18.428      31 CONTINUE
 18.43          DO 343,J=1,22
 18.45          DO 343,K=1,10
 18.47          PEOPLE(J,K)=0
 18.49      343 CONTINUE
```

```
      DISPLAY"TYPE THE YEAR WHEN PROGRAM IS TO START"
      DISPLAY"ANY YEAR FROM 1970 TO 1979"
      ACCEPT NYEAR
      DISPLAY"TYPE HOURS OF PROGRAM GENERATED PER WEEK AT THE BE
      GINNING"
      DISPLAY"AND AT THE END OF THE PROGRAM"
      ACCEPT HOURS(NYEAR-1969),HOURS(10)
      DISPLAY"TYPE THE DOLLAR COST OF ONE HOUR OF A NEW PROGRAM"
      ACCEPT DOLLAR
      SPAN=1980-NYEAR
      RATE=(HOURS(10)/HOURS(NYEAR-1969))↑(1/SPAN)
      PERSONNEL COSTS(NYEAR-1969)=HOURS(NYEAR-1969)*DOLLAR*52/3
      DO 40,K=(NYEAR-1969),10
      HOURS(K+1)=HOURS(K)*RATE
      OLD=(2/3.)*HOURS(K)
      FRESH=HOURS(K+1)-OLD
      PERSONNEL COSTS(K+1)=FRESH*DOLLAR*52
      LUNIT=(HOURS(NYEAR-1969)/15)+1
      IF(HOURS(K).GT.HOURS(NYEAR-1969))LUNIT=(HOURS(K)/15)+1
      PEOPLE(1,K)=3+3.*(LUNIT-1)
      PEOPLE(2,K)=1+(3/2.)*(LUNIT-1)
      PEOPLE(3,K)=(.5)*(LUNIT-1)
      PEOPLE(4,K)=((LUNIT+1)/2.)*2
      PEOPLE(5,K)=(.5)*(LUNIT-1)
      PEOPLE(6,K)=1+(.25)*(LUNIT-1)
      PEOPLE(7,K)=1+(.25)*(LUNIT-1)
      PEOPLE(8,K)=1+(.25)*(LUNIT-1)
      PEOPLE(9,K)=1+(.75)*(LUNIT-1)
      PEOPLE(10,K)=1+(.25)*(LUNIT-1)
      PEOPLE(11,K)=1+(.25)*(LUNIT-1)
      PEOPLE(12,K)=1+(.25)*(LUNIT-1)
      PEOPLE(13,K)=(.5)*(LUNIT-1)
      PEOPLE(14,K)=7+7.*(LUNIT-1)
      PEOPLE(15,K)=3+3.*(LUNIT-1)
      PEOPLE(16,K)=2+1.*(LUNIT-1)
      PEOPLE(17,K)=1+(LUNIT-1)
      PEOPLE(20,K)=1
      PEOPLE(21,K)=1
      PEOPLE(22,K)=1
      STUDIOS(NYEAR-1969)=(HOURS(NYEAR-1969)/15)+1
      STUDIOS(K)=STUDIOS(NYEAR-1969)
      IF(FRESH.GT.HOURS(NYEAR-1969))STUDIOS(K)=(FRESH/15)+1
   40 CONTINUE
      X=PERSONNEL COSTS(NYEAR-1969)/52
      DO 543,L=1,7
      DO 543,K=1,10
      ANCSTS(L,K)=0
  543 CONTINUE
   52 CONTINUE
      HPW=HOURS(NYEAR-1969)
```

```
52.7          NEEDEDSTUDIOS=STUDIOS(NYEAR-1969)
52.9          DISPLAY "FOR",HPW," HRS PER WEEK OF FINAL  MATERIAL,",NEED
              EDSTUDIOS," STUDIOS ARE NEEDED"
53.1      889 FORMAT(19HEQUIPMENT COSTS FOR,I3,14H STUDIOS ARE:$,F7.1,10
              H THOUSANDS)
53.2          EQUIPCSTS=NEEDEDSTUDIOS*191830.
53.5          WRITE(1,889)NEEDEDSTUDIOS,EQUIPCSTS/1000.
53.8          BUILDCOSTS=(15000*NEEDEDSTUDIOS)*5
54.1          WRITE(1,890)BUILDCOSTS/1000.
54.2      890 FORMAT(32HBUILDING COSTS FOR STUDIOS ARE $,F7.1,10H THOUSA
              NDS)
54.4          TOTSTUDIO=EQUIPCSTS +BUILDCOSTS
54.7          DISPLAY "TOTAL STUDIO COSTS ARE $",TOTSTUDIO
54.8          DO 998,IJ=(NYEAR-1969),10
54.9          EQUIPCSTS=STUDIOS(IJ)*191830
55.           BUILDCOSTS=15E3*STUDIOS(IJ)*5
55.3          AMORTEQCSTS=EQUIPCSTS/5
55.6          AMORTBLDCSTS=BUILDCOSTS/30
55.9          EQUTIL=AMORTEQCSTS/10
56.2          BULDUTIL=AMORTBLDCSTS/20
56.3          ANCSTS(2,IJ)=AMORTEQCSTS+EQUTIL
56.4          ANCSTS(3,IJ)=AMORTBLDCSTS+BULDUTIL
56.45     998 CONTINUE
56.46         WRITE(1,443)STUDIOS(10)*266830.
56.47     443 FORMAT(5HAND $,F8.0,11H AT THE END)
56.48         DISPLAY" "
56.5          DISPLAY"TYPE IN NO. OF SETS AT THE START,AND AT THE END"
56.51         DISPLAY"OF THE PROGRAM"
56.52         ACCEPT STO,ST
56.521        L=NYEAR-1969
56.53         RATE=(ST/STO)↑(1/(10.-L))
56.531        ST=STO/RATE
56.54         DO 71,JJ=L,10
56.55         ST=ST*RATE
56.56         SETS(JJ)=ST/1E3
56.57      71 CONTINUE
57.4       99 FORMAT(F6.1)
57.7          PREVYRS=0
57.705        DISPLAY" "
57.71         DISPLAY"TYPE YEARLY SALARY OF TEACHERS' INSTRUCTOR"
57.72         ACCEPT SA
57.73         DISPLAY" "
57.74         DISPLAY"TYPE YEARLY SALARY ,TRAVEL COSTS OF SET MAINTENANC
              E TECHNICIAN"
57.75         ACCEPT TEC,TRA
58.           DO 173,L=(NYEAR-1969),10
58.3          ANCSTS(7,L)=0
58.6          ANCSTS(1,L)=PERSONNEL COSTS(L)
59.5          SETNEW=SETS(L)-PREVYRS
```

```
          C:TEACHEDWK=TRAINING (INITIAL 8 WEEKS +REFRESHER OF
      2 WEEKS)
      TEACHEDWK=(SETNEW*1000*1.8*8)+(PREVYRS*1000*1.8*2)
      WKINSTR=(TEACHEDWK/40)/40
      PREVYRS=SETS(L)
      ANCSTS(4,L)=WKINSTR*SA
      ANCSTS(6,L)=((SETS(L)*1E3)/80)*(SA+TRA)*.1
      PEOPLE(18,L)=SETS(L)*1E3/80.
      SET(L)=SETS(L)
  173 CONTINUE
      DISPLAY " ."
      DISPLAY "                  ANNUAL PROGRAMMING AND TEACHER TRAINI
      NG COSTS"
      DISPLAY "                INCLUDING OVERHEAD AND AMORTIZATION ($
      THOUSANDS)"
      DISPLAY " "
      DISPLAY " "
      DISPLAY "                         1970 1971 1972 1973 1974 1975
      1976 1977 1978 1979"
      DISPLAY "                         ---- ---- ---- ---- ---- ----
      ---- ---- ---- ----"
      DO 174, L=1,7
      DO 174,K=1,10
          C:PAPER SUPPORT @ 3 SHEETS/TEACHER/LESSON
      SHEETS=HOURS(K)*SETS(K)*1000*3*40*3
      SHEETS=SHEETS*.3
          C:ASSUMES .3 OF COURSES REQUIRE PAPER SUPPORT
      SHSTUP=HOURS(K)*3*(17+17)*40
      ANCSTS(5,K)=SHSTUP+((SHEETS/1E5)*200)
      ANCSTS2(L,K)=ANCSTS(L,K)/1000
      ANCSTS(7,K)=ANCSTS(L,K)+ANCSTS(7,K)
  174 CONTINUE
      DO175,L=1,7
      WRITE(1,556)COSTCATEG(L,1),COSTCATEG(L,2),COSTCATEG(L,3),(
      ANCSTS2(L,K),K=1,10)
  175 CONTINUE
  556 FORMAT (3A6,X,10I5)
      DISPLAY " "
      DISPLAY"TV SETS IN USE ARE: (THOUSANDS)"
      WRITE (1,667)(SETS(K),K=1,10)
  667 FORMAT(18X,X,10(F4.1,X))
      DO 85,J=1,10
      IF(SETS(J).EQ.0)GOTO 85
      MEN=(SETS(J)*1000/400)+1
      PEOPLE(19,J)=MEN
      SALARY=MEN*(TEC+TRA)/1000.
      SETS(J)=SALARY
   85 CONTINUE
      DISPLAY"SET MAINTENANCE COSTS ARE:"
      DISPLAY" "
      WRITE(1,667)(SETS(K),K=1,10)
         C:ASSUMES 1MAN CARES FOR 400 SETS
      DISPLAY" "
      DO 56,L=1,10
      ANCSTS2(7,L)=ANCSTS2(7,L)+SETS(L)
      SET(L)=SET(L)*200
   56 CONTINUE
      DISPLAY"THE OVERALL ANNUAL COSTS ARE:"
      WRITE(1,669)(ANCSTS2(7,J),J=1,10)
  669 FORMAT(18X,X,10(I4,X))
      DISPLAY" "
      DISPLAY"THE COST OF SETS IS AS FOLLOWS:"
      WRITE(1,667)(SET(JM),JM=1,10)
      S=0
      DO 389,I=(NYEAR-1969),10
      S=S+SET(I)
  389 CONTINUE
      DISPLAY" "
      DISPLAY"THE COST OF ALL SETS IS:"
      WRITE(1,845)S
  845 FORMAT(F8.0,11H THOUSAND $)
      OPEN[2,/DES/,INPUT,SYMBOLIC]
      READ(2,875)(DES(K),K=1,22)
  875 FORMAT(10(A6,X))
      CLOSE(2)
      DISPLAY " "
      DISPLAY"THE STAFFING REQUIREMENTS ARE AS FOLLOWS:"
      DISPLAY" "
      WRITE(1,986)(1969+L,L=1,10)
      DO 676,LK=20,22
      WRITE(1,987)DES(LK),(PEOPLE(LK,KJ),KJ=1,10)
  676 CONTINUE
      DO 876,KL=1,19
  986 FORMAT(11X,10I6)
      WRITE(1,987)DES(KL),(PEOPLE(KL,KJ),KJ=1,10)
  987 FORMAT(A6,4X,10I6)
  876 CONTINUE
      END

>
```

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>LIST

 10.1          COMMON  WHICH,V,COSTMICRO,NT,JJ,VI,TOWNSE(15)
 10.11         COMMON  S3,START,MAJOR,COORDINATES(70,2),COO(15,2)
 10.2          COMMON  DISTANCE(25,25),TOWNS(71),PATH1(50),PATH2(50)
 10.3          COMMON  S1,OR,SEC,BSTATIONS,PREEMPT(100)
 10.31         COMMON  SUMS(26,6),SD,NSH,CENTERS(2,60),HOURS(2,60),FRACTIO
               N(60),COUNT,SM,LC,SELECT(26)
 10.32         COMMON MANY,ACOST,TAPE
 10.4          DISPLAY"A.J.LIPINSKI  STANFORD  RESEARCH  INSTITUTE"
 10.5          DISPLAY"THIS  PROGRAM  WILL  HELP  YOU  TO  CALCULATE"
 10.55         DISPLAY"COSTS OF  ALTERNATIVE  TERRESTRIAL  TRANSMISSION  SYST
               EMS"
 10.56         COUNT=0
 10.6          DISPLAY" "
 10.61         DO  19,IK=1,70
 10.62         DO  19,IM=1,2
 10.63         COORDINATES(IK,IM)=0
 10.64      19 CONTINUE
 11.           OPEN[3,/LA/,INPUT,SYMBOLIC]
 12.           K1=1
 12.02         J1=5
 12.04         DO  413,NJ=1,14
 12.06         READ(3,100)((COORDINATES(K,L),L=1,2),K=K1,J1)
 12.07     100 FORMAT(5(2(F6.2,X)))
 12.1          K1=K1+5
 12.12         J1=J1+5
 12.14     413 CONTINUE
 12.22         READ(3,909)(CENTERS(1,K),K=1,15)
 12.225        READ(3,951)(CENTERS(2,K),K=1,60)
 12.226    951 FORMAT(10(A6,X))
 12.23     909 FORMAT(10A7,/,5A7)
 12.24         READ(3,500)(TOWNS(JJ),JJ=1,70)
 12.26     500 FORMAT(10(A6,X))
 12.28         CLOSE(3)
 12.3          DO  9,IK=1,70
 12.31         DO  9,IM=1,2
 12.32         NIX=COORDINATES(IK,IM)
 12.33         DIF=COORDINATES(IK,IM)-NIX
 12.34         DEC=DIF*10/6.
 12.35         COORDINATES(IK,IM)=NIX+DEC
 12.36       9 CONTINUE
 13.221        DISPLAY"THE  COORDINATES  OF  MAJOR  TOWNS"
 13.223        DISPLAY"HAVE  ALREADY  BEEN  STORED  IN  MEMORY"
 13.225        DISPLAY"THEIR  ABBREVIATED  NAMES  ARE:"
```

```
      DISPLAY" "
      DISPLAY" "
      WRITE([illegible] 500)(TOWNS(JJ),JJ=1,70)
      DISPLAY" "
      DISPLAY"USING THE ABOVE ABBREVIATION TYPE THE NAME"
      DISPLAY "OF TOWN TO START FROM AND,THE NUMBER OF TOWNS TO
      BE LINKED"
      READ(0,501)START,MAJOR
  501 FORMAT(A6,X,I2)
      DISPLAY"USING THE SAME ABBREVIATIONS SELECT THE TOWNS TO B
      E LINKED"
      READ(0,503)(SELECT(JJ),JJ=1,MAJOR)
      JJ=MAJOR-1
  503 FORMAT(10(A6,X),/,10(A6,X))
      DO 463,LK=1,MAJOR
      DO 467,JM=1,70
      IF(TOWNS(JM).EQ.SELECT(LK))GOTO 468
      GOTO 467
  468 TOWNSE(LK)=SELECT(LK)
      COO(LK,1)=COORDINATES(JM,1)
      COO(LK,2)=COORDINATES(JM,2)
  654 FORMAT(A6,2F8.2)
      GOTO 463
  467 CONTINUE
  463 CONTINUE
      DISPLAY"CONFIRMING YOUR CHOICES:"
      WRITE(1,503)(TOWNSE(LL),LL=1,MAJOR)
      DISPLAY" "
      DISPLAY"ARE THESE NAMES RECEIVED CORRECTLY?"
      DISPLAY"IF YES TYPE 1 ELSE 2"
      ACCEPT NOYES
      IF(NOYES.EQ.2)GOTO 501
      DISPLAY" "
      DISPLAY"HOW MANY SUBCENTERS ARE TO BE FED FROM EACH MAIN C
      ENTER?"
      DO 538,K=1,MAJOR
      TOWNS(K)=TOWNSE(K)
      COORDINATES(K,1)=COO(K,1)
      COORDINATES(K,2)=COO(K,2)
  538 CONTINUE
      ACCEPT MANY
      COUNT=0
      ACOST=0
      TAPE=0
      OR=1
      DO 579,MX=(MAJOR+1),70
      TOWNS(MX)=0
      COORDINATES(MX,1)=0
      COORDINATES(MX,2)=0
  579 CONTINUE
```

```
13.4            S3=0
13.405          L1=100
13.41           DO 103,L=1,L1
13.42           PREEMPT(L)=0
13.43       103 CONTINUE
14.             DO 1,JJ=1,25
15.             DO 2,KK=1,25
16.             DISTANCE(JJ,KK)=0
16.5          2 CONTINUE
16.9          1 CONTINUE
16.91           SD=0
16.912          NSH=0
16.914          SM=0
16.916          LC=0
16.918          DO 109,I=1,26
16.92           DO 109,II=1,6
16.922          SUMS(I,II)=0
16.924      109 CONTINUE
17.01           DO 18,IL=1,50
17.02           PATH1(IL)=25E3
17.03           PATH2(IL)=0
17.04        18 CONTINUE
17.041      511 CONTINUE
17.042          CALL RESHUFFLE
17.05           N1=0
17.055          JJJ=MAJOR
17.06           JJ=MAJOR-1
17.41           DO 3,M=1,JJ
17.46           II=M+1
17.47           DO 4,N=II,JJJ
20.             HR=ABS[COORDINATES(M,1)-COORDINATES((N),1)]
21.             VR=ABS[COORDINATES(M,2)-COORDINATES((N),2)]
22.             HA=HR*3.14159/180
23.             VA=VR*3.14159/180
23.1            R=3959
23.2            P=3.14159
23.4            AN1=(COORDINATES(N,2)*P/180)
23.5            AN2=(COORDINATES(M,2)*P/180)
23.6            IF(COORDINATES(M,2).LT.COORDINATES(N,2))GOTO 889
23.7        888 CONTINUE
23.8            DU=AN1
23.9            AN1=AN2
24.             AN2=DU
24.1        889 CONTINUE
24.2            SL1=2*R*SIN[HA/2]*COS[AN1]
24.3            SL3=2*R*SIN[HA/2]*COS[AN2]
24.4            D1=SQRT[(R*VA)↑2+SL1*SL3]
24.5            DISTANCE(M,N)=R*(2*ATAN[(D1/(2*R))/SQRT[1-(D1/(2*R))↑2]])
25.           4 CONTINUE
26.           3 CONTINUE
```

```
      DISPLAY" "
      CLOSE (2)
      NT=1
   85 CONTINUE
      S1=0
      CALL BESTPATH
      DISPLAY"IF YOU WISH TO COMMUNICATE DIRECTLY FROM"
      WRITE(1,800) TOWNS(NT),TOWNS(SEC)
  800 FORMAT(A6,4H TO ,A6,14H TYPE 1,ELSE 2)
      ACCEPT K
      WHICH=SEC
      IF(K.EQ.2)WHICH=OR
   68 CONTINUE
      CALL MICROWAVE
      IF(WHICH-SEC)66,67,66
   67 WHICH=OR
      GOTO 68
   66 CONTINUE
      NT=OR
      START=TOWNS(OR)
      DISPLAY"WE MOVE TO"
      WRITE(1,600) TOWNS(NT)
  600 FORMAT(A6)
      GOTO 511
      GOTO 85
      DISPLAY " "
      END


      SUBROUTINE RESHUFFLE
      COMMON WHICH,V,COSTMICRO,NT,JJ,VI,TOWNSE(15)
      COMMON S3,START,MAJOR,COORDINATES(70,2),COO(15,2)
      COMMON DISTANCE(25,25),TOWNS(71),PATH1(50),PATH2(50)
      COMMON S1,OR,SEC,BSTATIONS,PREEMPT(100)
      COMMON SUMS(26,6),SD,NSH,CENTERS(2,60),HOURS(2,60),FRACTIO
      N(60),COUNT,SM,LC,SELECT(26)
      COMMON MANY,ACOST,TAPE
      JJJ=MAJOR
      JJ=MAJOR-1
      MM=MAJOR+1
      DO 61,I=1,JJ
      IF(TOWNS(1).EQ.START)GOTO62
      DUMP=TOWNS(JJJ)
      DUMP1=COORDINATES(JJJ,1)
      DUMP2=COORDINATES(JJJ,2)
      DO 63,J=1,JJ
      TOWNS(MM-J)=TOWNS(JJJ-J)
      COORDINATES((MM-J),1)=COORDINATES((JJJ-J),1)
      COORDINATES((MM-J),2)=COORDINATES((JJJ-J),2)
   63 CONTINUE
      TOWNS(I)=DUMP
      COORDINATES(I,1)=DUMP1
      COORDINATES(1,2)=DUMP2
   61 CONTINUE
   62 CONTINUE
      RETURN
      END


      SUBROUTINE VIDEOTAPE
      COMMON WHICH,V,COSTMICRO,NT,CJ,VI,TOWNSE(15)
      COMMON S3,START,MAJOR,COORDINATES(70,2),COO(15,2)
      COMMON DISTANCE(25,25),TOWNS(71),PATH1(50),PATH2(50)
      COMMON S1,OR,SEC,BSTATIONS,PREEMPT(100)
      COMMON SUMS(26,6),SD,NSH,CENTERS(2,60),HOURS(2,60),FRACTIO
      N(60),COUNT,SM,LC,SELECT(26)
      COMMON MANY,ACOST,TAPE
      RATE=2*45.74E-3
          C:BOLIVIA GRAVEL ROAD GO-RETURN TRUCK COSTS (45$/10
      00KM)
      DO 134,KI=1,60
      HOURS(2,KI)=0
  134 CONTINUE
      DO 615,J=1,15
      IF(TOWNS(NT).EQ.CENTERS(1,J))GOTO 616
  615 CONTINUE
      DO 617,JK=1,60
      IF(TOWNS(NT).EQ.CENTERS(2,JK))GOTO 618
  617 CONTINUE
      GOTO 609
  616 CONTINUE
      DO 619,JJ=1,60
      IF(TOWNS(WHICH).EQ.CENTERS(2,JJ))GOTO 620
  619 CONTINUE
      GOTO 609
  620 GOTO 607
  618 DO 621,KK=1,15
      IF(TOWNS(WHICH).EQ.CENTERS(1,KK))GOTO 622
  621 CONTINUE
      GOTO 699
  607 DISPLAY"HOW MANY HOURS PER WEEK ARE GENERATED AT:"
      WRITE(1,448) TOWNS(NT)
      ACCEPT HOURS(1,J)
      TRANSPORT=HOURS(1,J)*2
      STORE=TRANSPORT*6.5
      TAPE=20*TRANSPORT*49E-3
      TAPE=TAPE+2.
      DISPLAY"THIS TAPE LIBRARY IS AT THE MAIN CENTER"
      DISPLAY"IT AMOUNTS TO  ",TAPE, " $ THOUSANDS"
      GOTO 623
  622 IF(COUNT.LE.MANY)GOTO 608
      GOTO 609
  608 CONTINUE
      DISPLAY"HOW MANY HOURS PER WEEK ARE GENERATED AT:"
      WRITE(1,448) TOWNS(NT)
      ACCEPT HOURS(2,JK)
  448 FORMAT(A6)
      STORE=HOURS(2,JK)+33*VI
           C:OWN GENERATION PLUS PROGRAM SENT FROM MAIN CENTER
      STORE=STORE*13
      TAPE=15*VI*13*HOURS(2,JK)*49E-3
      TAPE=TAPE+2.
  623 COUNT=COUNT+1
      ACOST=(DISTANCE(NT,WHICH)*1.609*1.6)*RATE*20
           C:20 TRIPS,1.6 ALLOW. FOR ROAD DETOURS,IN DOLLARS
      IF(COUNT.LT.(MANY))GOTO 609
      DISPLAY"IF THIS IS THE LAST STATION IN THE CHAIN- ESTABLIS
      H THE NEXT"
      DISPLAY"CONNECTION SO THAT THE COST OF STATION AND OF TAPE
       LIBRARY"
      DISPLAY"ARE COUNTED IN THE SUMMARY"
      GOTO 609
  699 CONTINUE
      DO 689,JK=1,60
      IF(TOWNS(WHICH).EQ.CENTERS(2,JK))GOTO 679
  689 CONTINUE
      GOTO 609
  679 CONTINUE
           C:2 WEEK'S WORTH OF OWN GENERATION
      STORE=HOURS(2,JK)+33*VI
      DISPLAY"4 MONTH INVENTORY OF TAPE AMOUNTS TO: "
  445 FORMAT(F10.3,15H DOLLARS (1000))
      STORE=13*STORE
           C:4 MONTH'S INVENTORY
      TAPE=STORE*49E-3
      TAPE=TAPE+2.
      WRITE(1,445),TAPE
      GOTO 623
  609 CONTINUE
      RETURN
      END
      SUBROUTINE SUMMARY
      COMMON WHICH,V,COSTMICRO,NT,JJ,VI,TOWNSE(15)
      COMMON S3,START,MAJOR,COORDINATES(70,2),COO(15,2)
      COMMON DISTANCE(25,25),TOWNS(71),PATH1(50),PATH2(50)
      COMMON S1,OR,SEC,BSTATIONS,PREEMPT(100)
      COMMON SUMS(26,6),SD,NSH,CENTERS(2,60),HOURS(2,60),FRACTIO
      N(60),COUNT,SM,LC,SELECT(26)
      COMMON MANY,ACOST,TAPE
      DISPLAY" "
      ACOST=0
      TAPE=0
      CALL VIDEOTAPE
      DISPLAY"THE ANNUAL COST OF MICROWAVE IS ($THOUSANDS)"
      COST=COSTMICRO*.15
      WRITE(1,100)(COST*1000)
      DISPLAY"THIS IS THE LAST INVESTMENT"
      DISPLAY"CENTER-CENTER BR.ST($M) TV CH MICRO($M) ANSMI(M) T
      PTR($) INV($K)"
      WRITE(1,990)TOWNS(NT),TOWNS(WHICH),BSTATIONS/1E3,V,COSTMIC
      RO,COST,ACOST,TAPE
  990 FORMAT(A6,1H-,A6,F10.3,I4,2X,F9.3,F9.3,F8.2,F8.3)
  100 FORMAT(F6.1)
      DISPLAY"DO YOU WISH TO INCLUDE THESE NUMBERS IN THE COST S
      UMMARY?"
      DISPLAY"TYPE 1 (YES), 2(NO)"
      ACCEPT NOYES
      IF(NOYES.EQ.2)GOTO 338
      LC=LC+1
      DO 45,LG=1,6
      SUMS(26,LG)=0
   45 CONTINUE
      SUMS(LC,1)=BSTATIONS/1E3
      SUMS(LC,2)=COSTMICRO
      SUMS(LC,3)=TAPE/1E3
      SUMS(LC,4)=COST
      SUMS(LC,5)=ACOST/1E6
      SUMS(LC,6)=0
      IF(SUMS(LC,3).GT.0)SUMS(LC,6)=.006
      IF(COUNT.GE.MANY)GOTO 657
      GOTO 647
  657 DISPLAY"IS THIS THE LAST BROADCAST STATION IN THE CHAIN?"
      DISPLAY"IF YES TYPE 1,ELSE 2"
      ACCEPT NOYES
      IF(NOYES.EQ.2)GOTO 647
      DISPLAY"THE ONLY EXPENSE  WILL BE BROADCAST STATION AND LI
      BRARY"
      SUMS(LC,4)=0
      SUMS(LC,5)=0
  647 CONTINUE
      DO 33,KK=1,6
      DO 33,MM=1,25
      SUMS(26,KK)=SUMS(26,KK)+SUMS(MM,KK)
   33 CONTINUE
  338 CONTINUE
      DISPLAY" "
      DISPLAY"THIS IS THE SUMMARY SO FAR"
      DISPLAY" "
      DISPLAY"   FIRST COST ($ MILLIONS)              ANNUAL COST (
      $ MILLIONS)"
      DISPLAY"BR.STATIONS \MICROWAVE TAPE LIBR.  MICROWAVE TAPE
      TR.(TRUCK) LIBR."
      DISPLAY" "
      X=.006
      WRITE(1,602)(SUMS(26,L),L=1,6)
  602 FORMAT(F9.3,2F10.3,6X,F8.3,F10.6,5X,F6.3)
      DISPLAY" "
      RETURN
      END


      SUBROUTINE BESTPATH
      COMMON WHICH,V,COSTMICRO,NT,JJ,VI,TOWNSE(15)
      COMMON S3,START,MAJOR,COORDINATES(70,2),COO(15,2)
      COMMON DISTANCE(25,25),TOWNS(71),PATH1(50),PATH2(50)
      COMMON S1,OR,SEC,BSTATIONS,PREEMPT(100)
      COMMON SUMS(26,6),SD,NSH,CENTERS(2,60),HOURS(2,60),FRACTIO
      N(60),COUNT,SM,LC,SELECT(26)
      COMMON MANY,ACOST,TAPE
      N1=0
      N=MAJOR
      NX=NT+1
      L1=100
      DO 81,KJ=2,MAJOR
      DO 71,L=1,S3
      IF(DISTANCE(1,KJ).EQ.PREEMPT(L))GOTO 81
   71 CONTINUE
      N1=N1+1
      PATH1(N1)=DISTANCE(1,KJ)
   81 CONTINUE
      GOTO 83
   82 DISPLAY"AFTER THAT"
      SEC=K1
      WHICH=SEC
   83 CONTINUE
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84.            BEST=PATH1(1)
84.1           DO 13, J=1,49
84.2           IF(PATH1(J+1).LT.BEST)BEST=PATH1(J+1)
84.3        13 CONTINUE
84.5              C:WHICH DISTANCE IS THE SHORTEST?
85.            J=1
86.            II=J+1
86.1           JJJ=MAJOR
87.            DO 19,K=II,JJJ
88.            IF(DISTANCE(J,K).EQ.BEST)GOTO57
89.         19 CONTINUE
89.1        57 J1=NT
89.15          K1=K
89.16          SEC=K1
89.2           WRITE(1,400) TOWNS(1),TOWNS(K1),DISTANCE(1,K1)
89.3       400 FORMAT(21HTHE NEXT CENTER FROM ,A6,4H IS ,A6,F6.0,10HMILES
                AWAY)
89.4           NT=1
89.8           DO 21,K=1,50
90.1           IF(PATH1(K).EQ.BEST)GOTO 22
90.2        21 CONTINUE
90.3        22 PATH2(K)=PATH1(K)
90.4           PATH1(K)=25E3
90.5           S1=J1+1
0.55           IF(S1.EQ.1)OR=K1
0.6            IF(S1.EQ.1)GOTO 82
90.65          RETURN
90.7           END



91.            SUBROUTINE MICROWAVE
91.01          COMMON WHICH,  V,COSTMICRO,NT,JJ,VI,TOWNSE(15)
91.02          COMMON S3,START,MAJOR,COORDINATES(70,2),COO(15,2)
91.03          COMMON DISTANCE(25,25),TOWNS(71),PATH1(50),PATH2(50)
91.04          COMMON S1,OR,SEC,BSTATIONS,PREEMPT(100)
91.06          COMMON SUMS(26,6),SD,NSH,CENTERS(2,60),HOURS(2,60),FRACTIO
               N(60),COUNT,SM,LC,SELECT(26)
91.07          COMMON MANY,ACOST,TAPE
91.161         S2=0
91.17       87 CONTINUE
91.18          S2=S2+1
91.185         S3=S3+1
91.19          WRITE(1,709) TOWNS(NT)
91.191     709 FORMAT(36HIS THERE A ETV BROADCAST STATION IN  ,A6)
91.192         DISPLAY"1(YES),2(NO)"
91.193         ACCEPT BR
91.194         DISPLAY"HOW MANY VIDEO CHANNELS ARE TO BE BROADCAST?"
91.199         ACCEPT VI
91.2           DISPLAY"HOW MANY VIDEO CHANNELS ARE NEEDED BETWEEN"
1.21           WRITE(1,700) TOWNS(NT),TOWNS(WHICH)
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      ACCEPT V
      IF((BR.EQ.1).AND.(VI.EQ.1))GOTO 719
      IF((BR.EQ.2).AND.(VI.EQ.0))GOTO 678
      BSTATIONS=100+413*VI
      IF(BR.EQ.2)BSTATIONS=545+(VI)*413
      GOTO 721
719   CONTINUE
      BSTATIONS=0
721   CONTINUE
      IF(V.EQ.0)GOTO 678
      DISPLAY"IS THERE A TV LINK BETWEEN"
      WRITE(1,700) TOWNS(NT),TOWNS(WHICH)
700   FORMAT(A6,1H-,A6,1H?)
      DISPLAY"TYPE 1 FOR YES, 2 FOR NO"
      ACCEPT I
      NHOPS=DISTANCE(NT,WHICH)/25
      COSTMICRO=NHOPS*(.25+(.03*V))
      IF(I.EQ.1)COSTMICRO=NHOPS*(.03*(V))
      PREEMPT(S3)=DISTANCE(NT,WHICH)
      CALL SUMMARY
678   CONTINUE
      PREEMPT(S3)=DISTANCE(NT,WHICH)
      IF(S2.EQ.2)GOTO 86
      IF((S2.EQ.1).AND.(WHICH.EQ.OR))GOTO 86
      IF((S2.EQ.1).AND.(WHICH.EQ.SEC))WHICH=OR
      GOTO 87
86    RETURN
      END

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Working Paper No. 7

THE ROLE OF RADIO IN SUPPORTING EDUCATIONAL TELEVISION

by Andrew D. Cohen

Although major emphasis has been given to television in the case studies of India and Latin America (Volumes II and III of this report series), there has been some mention of educational radio. The field trip notes in Appendix B of the Latin America case study (especially those for Colombia, Peru, and Bolivia) and the first Appendix in the India case study (pp. A-15 to A-19) comment on efforts in educational radio. Further, the India case study compares the effectiveness of radio and television (pp. 23, 53-57) and suggests that radio stations could be a source of programming for rural villages until funds and experience are available for extending television into the rural zones (pp. 80-81).

This paper takes the use of radio a step further. Instead of considering radio education only as a transitional step to be used until television is available, it might be worthwhile for education officials to consider combining both radio and television in one system. Radio may well be useful as a stopgap medium, but once television reaches radio listeners, the two media together could be more effective than either one used singly.

Radio correspondence courses have had sufficient success (India case study, p. 50) to show that radio can be used for instructional purposes. Deficiencies in radio instruction often lie with the quality of the programming, rather than with the shortcomings of radio as a medium of instruction. Thus, used properly, radio instruction may be an asset to an ETV program. In fact, Japan's broadcast-correspondence high school has proved that radio can be used effectively in combination with television. Japan has enjoyed success with this type of system since 1963.* Courses are scheduled so that the same subject is not broadcast simultaneously on radio and television. This ensures that one teacher can teach the same subject live on both media, so as to bring a similar program to those without access to television sets. Also, a student who wishes to gain extra help by hearing the subject discussed twice may do so.

The effectiveness of educational broadcasting, whether radio or television, depends on the quality of the programming. Producers for both media share common concerns, such as that of pacing the presentation. Programmers must ask themselves: What pace is satisfactory to all students? And a related question: Can one medium alone meet the diverse needs of the student audience?

Joint radio-television production may lighten the workload of each medium individually. Special courses could be developed for radio and television in parallel. Such combined effort could be most sensitive to the unique features of each medium. Television would concentrate on developing audiovisual techniques to strengthen its core instruction. Radio would also provide core instruction and would further utilize its comparative advantage in providing low cost multiple channels for supplementary programs. For instance, radio could offer review programs for slower students, advanced work for faster students, or the same instruction in the local language. There could even be a more elaborate multiple-channel branching system for programmed teaching, so that a student could move ahead at his own pace, while receiving some or all of the regular ITV offerings as well.

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* Wilbur Schramm, et al., Educational Media in Action: Case Studies for Planners, UNESCO and International Institute for Educational Planning, Paris, France, 1967.

The radio programs would be transmitted not only to areas within television coverage, but also to areas without television. In this way, areas covered only by radio would have the benefit of the same curriculum broadcast over television. Well-trained radio-utilization teachers would be needed to supply the missing visual content, largely through blackboard drawings copied out of the teacher guidebooks. Then, as television is phased into the program, radio would assume a supportive role, rather than becoming obsolete.

A combined radio-television effort presupposes a commitment to integrating the broadcast media into the core of the curriculum, whether these media broadcasts are transmitted to formal school classrooms, to telecenters, or to the home. Programs of a purely supplementary nature may not call for such an elaborate operation. Furthermore, supplementary programs may lend themselves better to television, as in the case of documentary films, or to radio, as in the case of folk music.

While supporting television, radio could also help to upgrade the performance of the teaching staff. Currently, inservice teacher training for TV-utilization teachers is limited to one Saturday morning television program per week. Since teachers must go to school to view these programs (or find another television set), attendance at these sessions is poor. Radio could bring such programs to the home, perhaps on a more regular basis. For instance, 30 minutes each evening could be set aside for inservice teacher training. These sessions could also be used to train the teachers in new math and other new curricula.

Radio can also provide on-the-job support for teachers. Particularly where telesecondary schools offer the first secondary education in an area, the teachers are usually local residents who are inadequately prepared for the courses they are supposed to teach. While their experience may have been in 5th-grade teaching, they are to be TV-utilization teachers for the 7th and 8th grades. The television broadcast itself constitutes only a small portion of the overall class time, and the teacher must fill up the rest. Given concurrent radio programming, teachers who are unsure of themselves could call on the radio broadcasts for support--either in or out of class, or both.

Finally, and perhaps most significantly, radio can act as a reserve source of programming for television. Television sets are subject to maintenance problems. About 100 of Colombia's 1,250 sets are in the workshops for repair at any given time.* Often, sets break down at crucial moments in the instructional process. With a concurrent radio program, students and teachers could make use of radio offerings until the television set is working again. Especially if satellites are to be the source of programming, there may be need for the inexpensive backstopping device that radio could provide. It might happen, for instance, that a satellite must be replaced by another satellite in the middle of a school term, or ground station operators may have trouble with antennas. If radio programming is available to fill in during the television blackout, the educational process will not be disrupted by technical interruptions.

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* Jack Lyle, Colombia's Instructional Television Program for Primary Schools, Progress 1965-68, The Ford Foundation, Bogotá, Colombia, February 23, 1968, p. 7.

In conclusion, developing countries might well profit from making parallel use of radio and television in teaching core instruction. Media planners should think in terms of coordinating the programming of both. Several developing countries are realizing this need for coordination, and, as a first step, have established a national planning group, such as INTE in Peru. Colombia has set up a National Institute for Radio and Television. Private institutions, such as TelePuno, in Puno, Peru, have also begun coordinated efforts. Given the needs for education and the limited resources at their disposal for harnessing new technologies to meet these needs, educational policy-makers in developing countries will want to use that combination of radio and television media that offers reliability and maximum effectiveness.